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THE
Post Office Electrical Engineers' Journal

START-STOP PRINTING TELEGRAPH SYSTEMS.

(*Continued.*)

A. E. Stone, A.R.C.Sc.

(III.). The Teleprinter No. 3A.

THE generic name of "Teleprinter" has now been allotted to all types of start-stop telegraph apparatus. The Morkrum Teletypes No. 1A and No. 2A, described in previous issues of this Journal, are now designated Teleprinters No. 1A and No. 2A respectively, while the title Teleprinter No. 3A has been given to a start-stop instrument, designed by Messrs. Creed and Co., the use of which is being greatly extended by the Department.

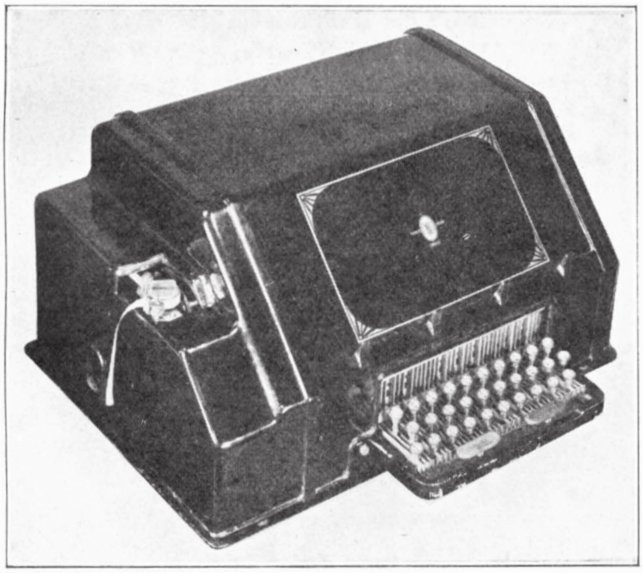


Fig. 1.—Teleprinter No. 3A.

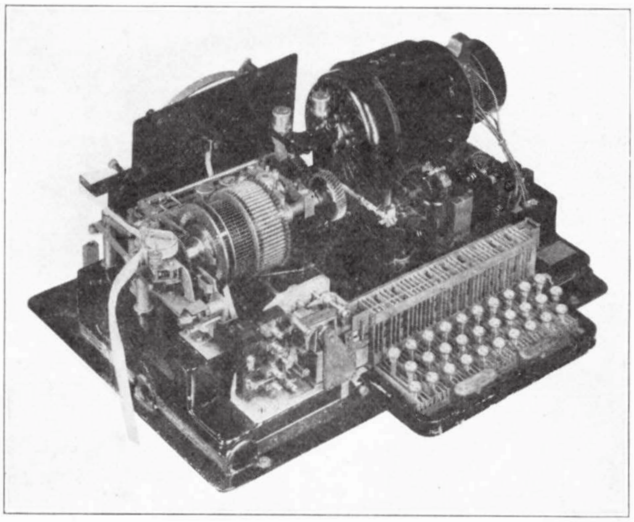


Fig. 2.—Teleprinter No. 3A with Cover removed.

Fig. **1** is a general view of the Teleprinter No. 3A, and Fig. **2** shows the arrangement of the mechanism. It consists of a typewriter keyboard transmitter and a tape-printing receiver, independently driven by a single shunt-wound motor of 1/12th H.P., but mounted on the same base. The motor runs continuously, but the transmitting and receiving mechanisms are at rest when signals are not being transmitted over the circuit. The operating speed is 60 words per minute.

SIGNALLING CODE

LTRS	FIGS	UNITS					LTRS	FIGS	UNITS				
		1	2	3	4	5			1	2	3	4	5
A	:	●	●	○	○	○	Q	1	●	●	●	○	●
B	?	●	○	○	●	●	R	4	○	●	○	●	○
C	(	○	●	●	●	○	S	'	●	○	●	○	○
D	2	●	○	○	●	○	T	5	○	○	○	○	●
E	3	●	○	○	○	○	U	7	●	●	●	○	○
F	1/	●	○	●	●	○	V	)	○	●	●	●	●
G	3/	○	●	○	●	●	W	2	●	●	○	○	●
H	5/	○	○	●	○	●	X	£	●	○	●	●	●
I	8	○	●	●	○	○	Y	6	●	○	●	○	●
J	7/	●	●	○	●	○	Z	.	●	○	○	○	●
K	9/	●	●	●	●	○	/	/	○	●	○	○	○
L		○	●	○	○	●	✳	✳	●	●	●	●	●
M	'	○	○	●	●	●	–	=	○	○	○	●	○
N	–	○	○	●	●	○		+	○	●	○	○	●
O	9	○	○	○	●	●	LETTER SPACE		○	○	●	○	○
P	0	○	●	●	○	●	FIGURE SPACE		●	●	○	●	●

SHADED CIRCLES DENOTE MARKING SIGNALS.

Fig. 3.

Fig. **3** shows the arrangement of the five-unit code used, and it will be seen that, apart from a few secondary characters, it is the same as for the Morkrum instruments. The start signal, however, which precedes a character combination, is a marking impulse and the stop signal a spacing impulse, *i.e.*, just the opposite to the Morkrum apparatus with which the start and stop signals are *spacing* and *marking* impulses respectively.

Transmitter Clutch Trip Mechanism.—A cam sleeve, which is at rest normally, controls all the mechanical operations of the Transmitter. When any key lever of the keyboard is depressed, a motor-driven spindle causes the cam sleeve to make one revolution and then stop. This is effected as follows:—

Referring to Fig. **4**, RW is a Ratchet Wheel driven continuously by the motor in the direction shown. Pivoted on the Cam Sleeve, which surrounds RW, are two Pawls P. The Pawl Abutment PA holds these pawls, normally, in such a position that their hooked ends do not engage with the teeth of RW.

On depressing a Key Lever, the Trip Bar TB moves downwards, causing the upper end of TL to move the Cam Trip Lever CTL to the right. The latter engages with the lower end of PA, thereby lifting the upper extremity away from the Pawls. Immediately this occurs, the Pawl Spring PS, encircling the Cam Sleeve, forces the hooked ends of the Pawls into engagement with RW and the Cam Sleeve with its various Cams commences to rotate. One of the Cams, C, as it rotates, pushes CTL down until it disengages from the forked end of PA; the latter is then restored to its original position by the Spring S1, so that its upper end is in position to intercept the pawls, withdraw them from RW and thus stop the Cam Sleeve at the end of one revolution.

Keyboard Locking Arrangement.—In order to ensure that the proper sequence of impulses shall be sent when a key lever is operated it is necessary (*a*) to prevent another key from being operated when one key is already depressed, and (*b*) to prevent a depressed key from rising until the signal combination has been transmitted.

For this purpose two Locking Bars, LB1 and LB2, are provided as shown in Fig. **4**. LB2 is pivoted at Y and normally its front edge is just clear of the extremities E of the key levers. When a key lever is depressed, the Trip Bar TB turns about its pivot X, and the lower end of *m*, which is attached to X, moves downwards. Spring S4 then pulls the end of *n*, which is fixed to the pivot Y, downwards, thus causing LB2 to move forward under the extremities of all the remaining key levers, in which position it prevents them from being depressed. As soon as the key lever is released, TB will rise under the action of Spring S3, and LB2 will be restored to its original position by the action of the upper end of *m* on *n*. The Locking Bar LB1 is controlled by the Reset Lever RL. Immediately the Cam Sleeve starts to rotate, Cam C, which controls RL, allows LB1 to move to the right under the action of Spring S6 and one of its projections *h* enters a hole in the depressed key lever, holding it down until the Cam Sleeve has completed a revolution and Cam C has restored LB1 to its original position.

Transmitting Mechanism.—Underneath the Key Levers and at right angles to them are the Locking Bar LB1 and the five Combination Bars

CB1 to CB5, as shown in Fig. **5**. The upper edges of the latter have a series of projections arranged according to the signalling code and normally the bars are held to the left against the tensions of the Springs S, by the lower end of the Reset Lever RL, so that the projections do not come directly under the key levers. A key lever when depressed can therefore enter a set of notches between the projection of the Combination Bars. This is shown in Fig. **5** (Plan) where the black parts of the Combination Bars denote projections. The projections correspond to spacing units of the code, and the code for any particular key lever may be ascertained from the projections immediately to the left of it. Thus for A, the code is 1, 2, marking, and 3, 4, 5, spacing; and for Q, 1, 2, 3, 5, marking, and 4 spacing.

Each Combination Bar has a vertical extension E and associated with it is a Selecting Lever L, which is constrained by spring S7 to ride on the surface of a Cam on the Cam sleeve. There are five Selecting Levers, L1 to L5, and five Cams, C1 to C5, corresponding to the five Combination Bars. In addition there is a sixth Selecting Lever L6 operated by a sixth Cam C6, but there is no Combination Bar associated with L6. The function of L6 is to send the " Start " impulse. The lower ends of all the Selecting Levers bear against the upper part of the Actuating Lever AL, the forked end of which embraces the insulated end of the Transmitting Tongue TT. The latter plays between the contacts S and M, which are connected to the line battery, and normally it rests against S. (See also Fig. **6**).

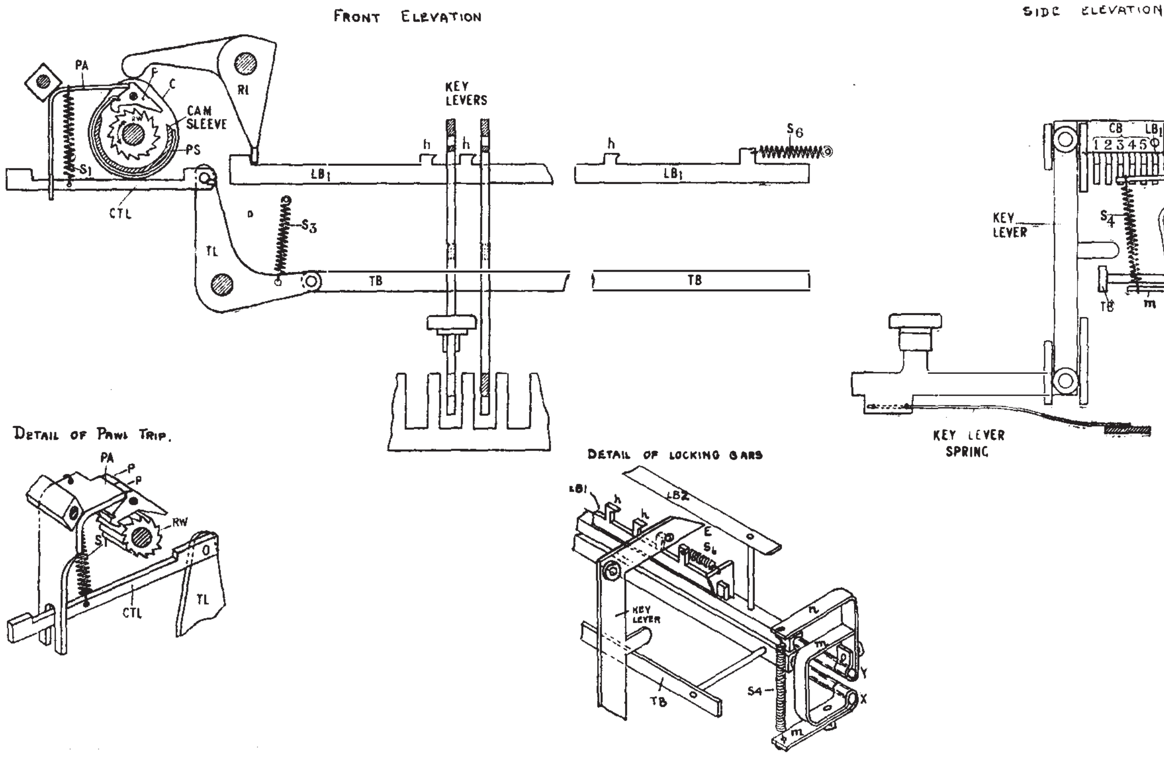


FIG. **4**.

The action of the Transmitter may be best explained by considering the following sequence of events occurring during the transmission of the letter Y, say, the code for which is 1, 3, 5, marking, and 2, 4, spacing :—

(*a*) When Key Lever Y is depressed it enters the notches in the Combination Bars, operates the Trip Bar which releases the Cam Pawls P (Fig. **4**), and the Cam Sleeve starts to rotate.

(*b*) Cam C (Figs. **4** and **5**) allows RL to release the Combination Bars, and also LB1 which when it moves to the right locks the key lever Y. Of the Combination Bars, only 1, 3 and 5 are pulled to the right by their springs; CB2 and CB4 are held in their normal positions because the projections on them butt against the depressed key lever. Accordingly extensions E1, E3 and E5 will move from under the ends of L1, L3 and L5, but E2 and E4 will remain under the ends of L2 and L4.

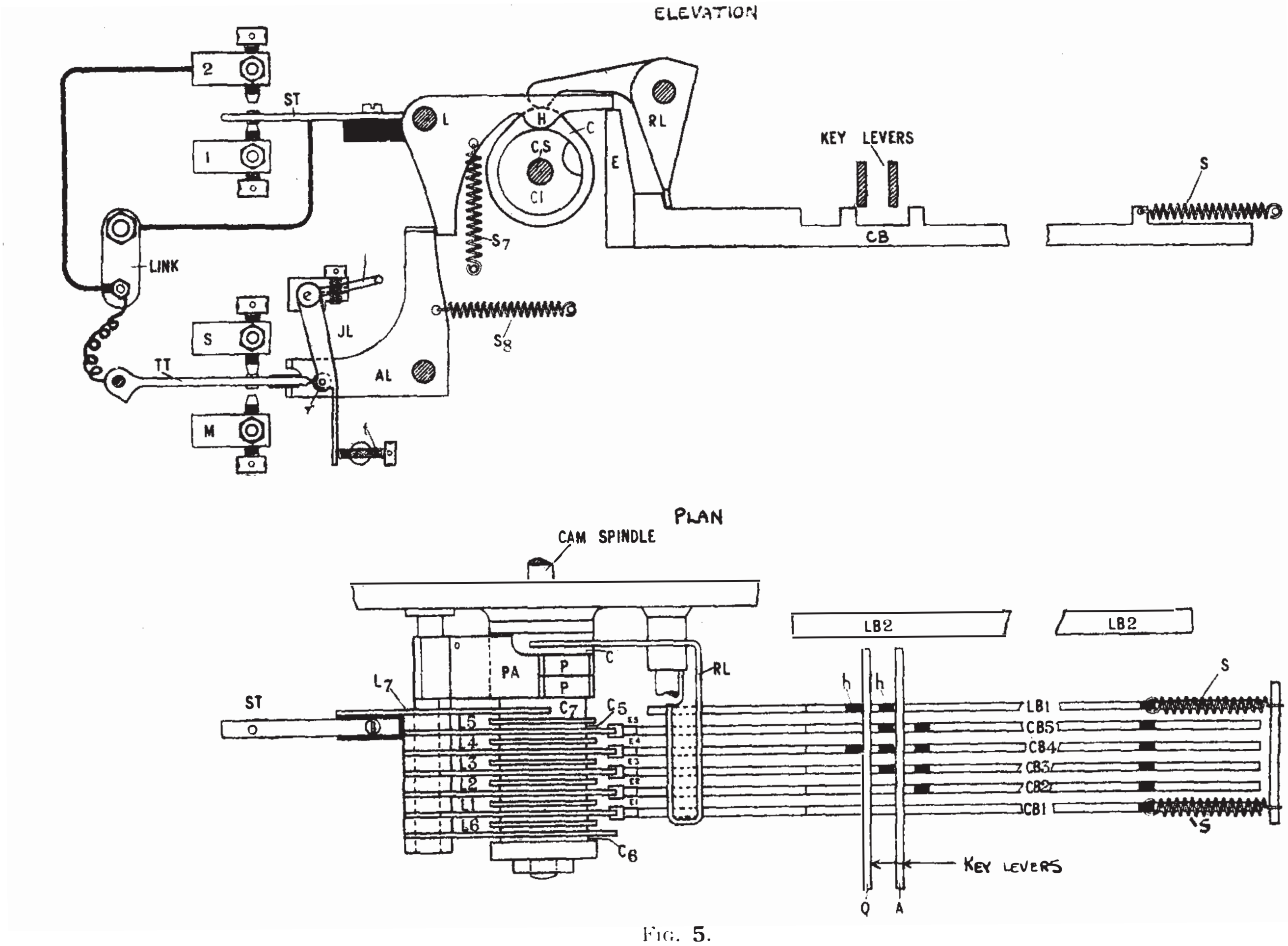


Fig. 5.

(c) As the Cam Sleeve rotates, the projection H on L6 will drop into the indent in Cam C6. The lower end of L6 will therefore move to the left, causing AL to turn anti-clockwise so that the upper part of its forked end will move TT to the "Marking" Contact M. This gives the "Start" impulse, the duration of which is fixed by the length of the indent in C6.

(d) Just as L6 is about to be restored to normal by C6, L1 falls into the indent in Cam C1, because it is free to do so, as E1 has moved to the right. Consequently TT will remain on the "Marking" Contact. Immediately L1 rides out of the indent in C1, L2 tends to drop into the indent in C2 but is prevented from so doing by E2, which is in its normal position directly under the end of L2. As a result, since L1 is now restored to its normal position, Spring S8 will cause AL to move clockwise and its forked end will move TT to the "Spacing" Contact S. Similarly, Cams C3, C4 and C5 will, in turn, cause AL to move TT to M, S and M respectively.

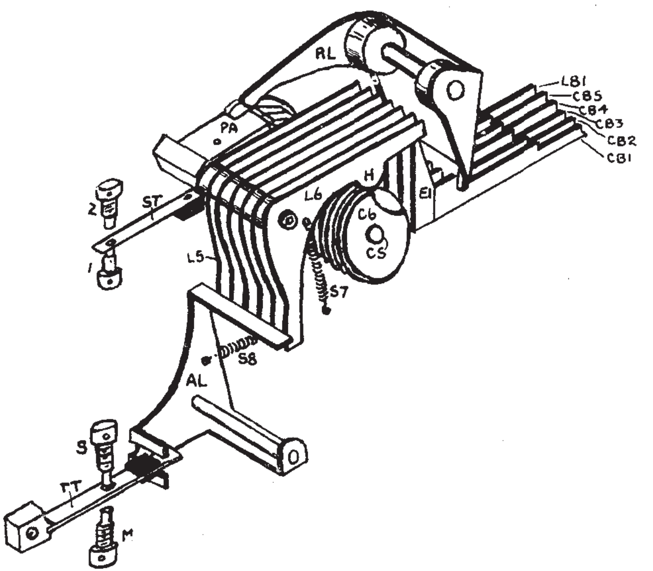


Fig. 6.

(*e*) When L5 rides out of the indent in C5, TT moves to " Spacing," and shortly afterwards Cam C operates RL, restoring LB1 which releases the key lever, and moving those Combination Bars that were pulled to the right, back to their normal positions.

(*f*) Finally the Clutch is disengaged and the Cam Sleeve comes to rest after making one revolution.

A Jockey Roller *r* mounted on the Lever JL, exerts sufficient pressure on the end of the Transmitting Tongue to give it a quick decisive movement from one contact to the other. The indents in the six transmitting Cams C6 and C1 to C5 are staggered to ensure that signals are sent out successively.

Printer Clutch Trip Mechanism.—The incoming signals from the distant station operate a Creed polarised relay mounted on the base of the instrument. This relay controls a " mechanical relay " which operates the Selecting and Printing mechanisms.

Referring to Fig. **7**, the motor spindle drives the disc *d*, the gear wheels W_1, W_2 and the Ratchet Wheel RW, which is fixed on the spindle of W_1, continuously. Mounted freely on the motor spindle is an Eccentric *e* carrying the Detent D. The friction between D and *d* is such that D, if unobstructed, would rotate with *d*; it is held in one of two positions, however, by the projections X and Y of the pivoted lever L which is controlled by the link attached to the relay armature. The arrangement is, in effect, an escapement and allows D to rotate half a revolution each time the relay armature moves from S to M or from M to S. The eccentric *e* turns with D and as it is embraced by the end of the rod H, it moves the latter first in one direction and then in the other as D completes the two halves of one revolution. Associated with the Ratchet Wheel RW is a Cam Sleeve upon which are pivoted two Pawls P as in the case of the Transmitter. These Pawls do not engage with the teeth of RW, normally and the Cam Sleeve is then stationary.

The first impulse received on the Creed Relay, being the " Start " signal, moves the relay armature to " marking " and the top of L will be moved to the left allowing D to rotate for half a revolution until it is stopped by the projection Y. This causes rod H to move to the right, turning the Trip Shaft TS, withdrawing the Trip Link TL and Pawl Abutment PA, so that the Pawls P can be forced, by the Pawl Spring, into engagement with RW. The Cam Sleeve accordingly starts to rotate. The final impulse in any character combination being the " Stop " signal moves the relay armature to " spacing " thus displacing L to the right and allowing D to rotate for half a revolution to the position shown in Fig. **7**, when it is stopped by the projection X which has been moved into its path

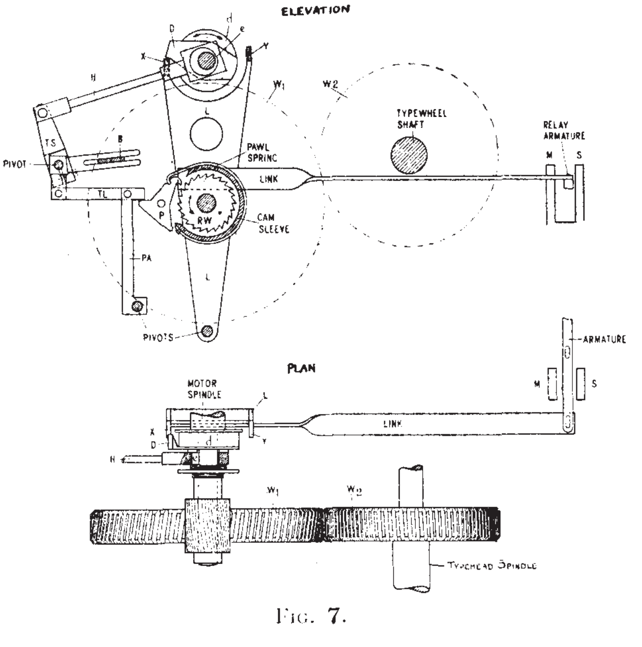


Fig. 7.

by L. Rod H is thus moved to the left and acting through TS and TL moves PA into such a position that the Pawls P are tripped out of engagement with RW at the end of one revolution of the Cam Sleeve which then comes to rest.

The Trip Shaft also controls the position of the Striker Blade B, the function of which will be described later. B is in the position shown when the relay armature is to " Spacing," and is tilted downwards when the armature moves to " Marking."

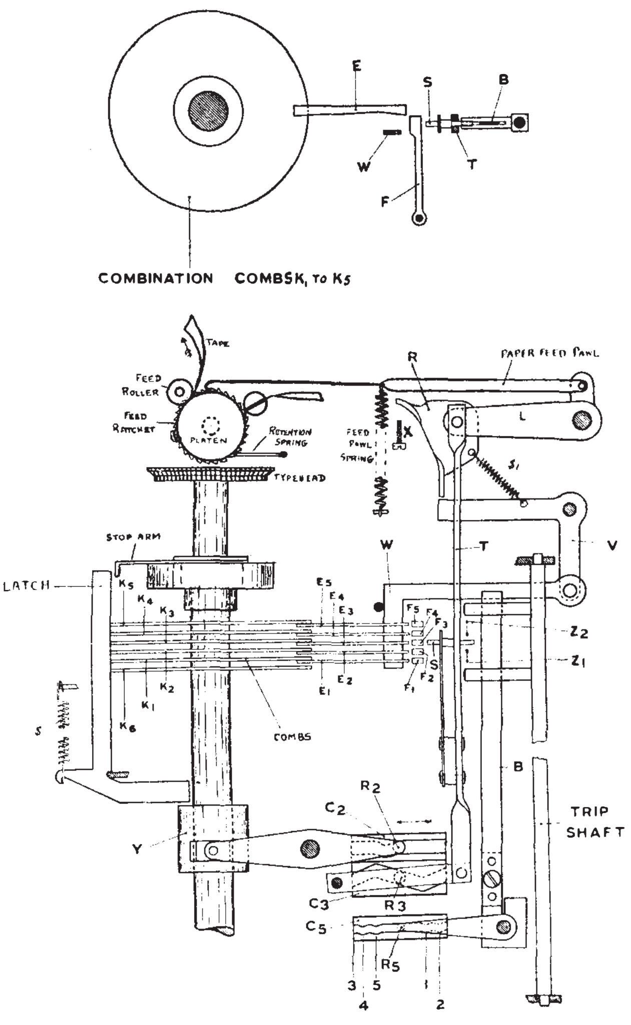


Fig. 8.

Selecting Mechanism.—In Fig. **8** K1 to K5 are five circular Combs each of which has a horizontal extension arm E. Directly in front of the extension arms are five Selecting Fingers F1 to F5. The Combs are mounted side by side on a drum and each can turn slightly if its extension be pushed upwards by the corresponding Selecting Finger. Opposite the Selecting Fingers is the Striker Pin S which is carried by the Traversing Link T.

The whole of the operations of the Printer are performed by five cams mounted on the Cam Sleeve. Three of these cams are shown in development in Fig. **8** and their functions are as follows :—

C2 operates the Sliding Sleeve Y for a purpose to be described later.

C3 controls the motion of the Traversing Link T, which carries the Striker Pin S backwards and forwards across the front of the Selecting Fingers.

C5, which has five indents in its track, causes the free end of the Striker Blade B to make successive movements towards the Pin S. These five indents are positioned relatvely to the track of C3 that the forward movements of B take place at such times as S is successively opposite each of the Fingers F1 to F5.

The normal positions of the three cam rollers R2, R3 and R5 on the cam tracks are as shown and the Pin S is opposite F3. The Cams move in the direction of the arrow. As already explained, the receipt of the " Start " signal sets the Cam Sleeve in rotation and C3 acting on roller R3 causes T to move in the direction of arrow Z1 so as to bring Pin S opposite F1 just as roller R5 moves into the first indent in C5. The free end of B will accordingly move towards S and will strike it, if the first impulse following the " Start " signal is a marking unit, but will miss it, if it is a Spacing unit, because the relay armature will then be on the Spacing side and B will be tilted upwards. When R5 moves into the second indent, S will be opposite F2 and so on for each successive indent in C5. When S is pushed forward by B, it moves the Selecting Finger F, immediately in front of it, underneath the corresponding extension arm E. In this manner as S traverses the front of the Selecting Fingers in the direction Z2, the latter are either pushed under the extension arms or remain *in situ* according to the position of the relay armature, and the selection is thus set up on the Fingers.

Printing.—Passing freely through the centre of the Combs is a continuously rotating spindle,

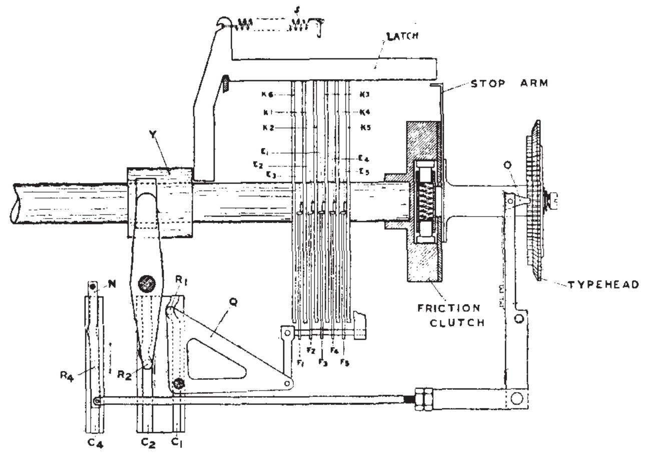


Fig. 9.

see Fig. **9**, carrying at one end a friction clutch which communicates the motion, normally, to a Typehead and Stop Arm. The Typehead consists of a number of small typebars mounted in the form of a vertical circle in which the letters of the alphabet alternate with figures and other characters as shown in Fig. **10**. Each Comb is slotted on its edge in a definite manner and can occupy one of two positions, one of which, in combination with any other combs that may have been moved, puts a set of slots in the five combs into alignment and allows one of a number of latches (depending on the character selected) to be pulled in under the action of a Spring $ (see Fig. **9**). The disposition of the latches and the combs is shown in Fig. **11**. If for example, Combs 3 and 5 are slightly displaced to the left, a set of slots is aligned in the five combs which allows latch H to be selected (the code for H is 1, 2, 4 spacing, and 3, 5, marking). When a latch is thus selected it acts as a lock to the Combs, and its free end projects into the path of the rotating Stop Arm (see Fig. **9**). The motion of the latter, and therefore that of the Typehead is arrested, the Clutch slipping to allow of this. When this occurs the required typebar of the typehead has been brought directly in front of the Printing Hammer O. Actual printing does not take place until near the end of the next revolution of the Cam Sleeve, when S is moving from F5 to F3. At a particular instant during this movement, the indent in Cam C4 operates lever N and cause the Hammer O to strike the selected typebar and thus record the character on a paper tape. The faces of the typebars are inked by contact with inked rollers. Immediately after printing, the indent in Cam C2 (Figs. **8** and **9**) moves sleeve Y forward and lifts the selected latch clear of the combs allowing any of the latter that were displaced to return to their normal positions under the action of springs. Finally just before the Cam Sleeve comes to rest, the indent in C1 (Fig. **9**) moves lever Q which raises the Selector Fingers. Those fingers that were pushed under the extension arms during the passage of S from F1 to F3 will accordingly lift the corresponding arms

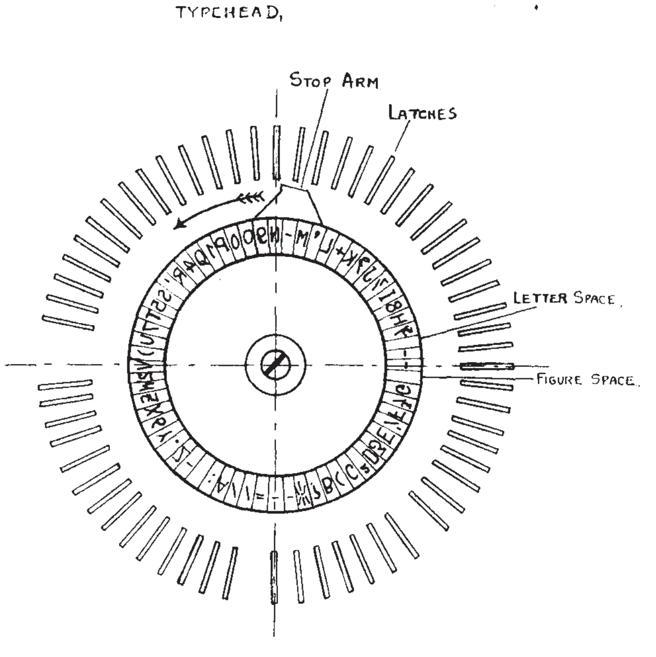


Fig. **10** (*a*).

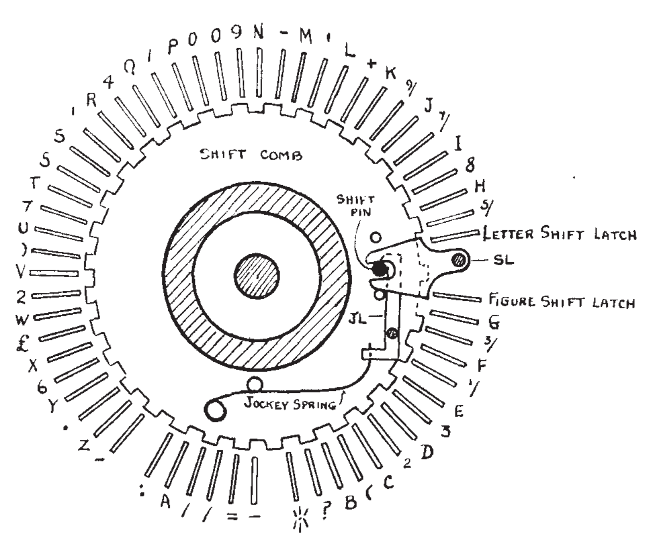


Fig. **10** (*b*).

and transfer the selection to the Combs. The printing of the character thus selected takes place near the end of the next revolution in the manner described.

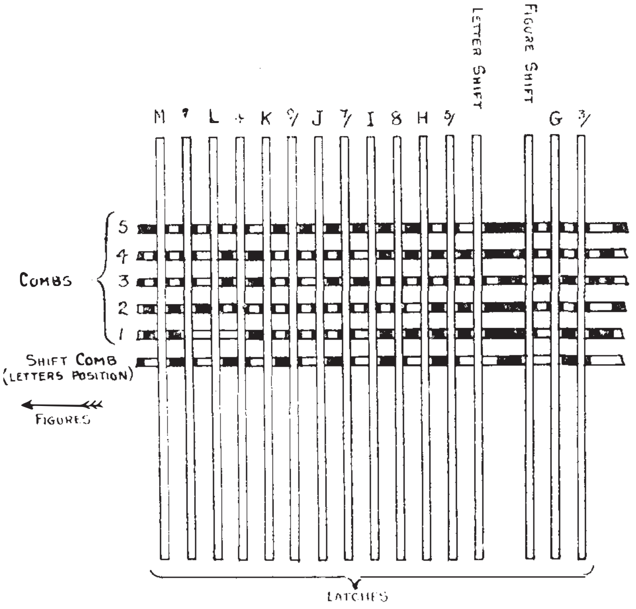


Fig. 11.

Finger Resetting Mechanism.—While S is moving from F3 to F1, Cam C1 (Fig. **9**) causes lever Q to lower the Selector Fingers which were raised to set the Combs just before the end of the previous revolution. At the same time the Selector Fingers that were pushed forward are restored to their normal positions so that they may be reset when S moves from F1 to F5. This resetting is effected as follows, Fig. **8** refers :—

The Resetting Link Lever V is held, normally, against the end of the bellcrank R by the spring $1. R is pivoted on the end of T and as the latter moves in the direction Z1, R will push against the end of V and move it to such an extent that the link W will push any Selector Fingers, which were set during the previous revolution, from under the Extension Arms E. Before T reaches the end of its stroke, the other extremity of R strikes the stop screw X and R is thrown out of engagement with V. As a result spring $1 turns V clockwise and W is thrust to the left so that it will be clear of the Selector Fingers when the next combination is being set up as T moves from F1 to F5. R is carried with T during this movement and ultimately its extremity again falls behind V.

Paper Feed Mechanism.—A roll of paper tape is mounted on a holder fixed inside the cover to the back of the Instrument. The paper is fed round a platen and led through an aperture in the left side of the cover. Fixed on the platen spindle is a Feed Ratchet which is driven by a Feed Pawl pivoted on the Bell Crank L (see Fig. **8**). The Traversing Link T operates L and when it moves in the direction Z1 the Feed Pawl is pushed forward and slips over one tooth of the Feed Ratchet; the Retention Spring holds the latter steady and prevents it from moving backward. The Feed Pawl engages with the Ratchet when T moves in the direction Z2 and turns the Platen so that the tape is fed forward one letter space. The Feed Pawl regains its normal position when T reaches its position of rest opposite F3.

Shift Mechanism.—Referring to Fig. **11** it will be seen that in addition to the five Combs

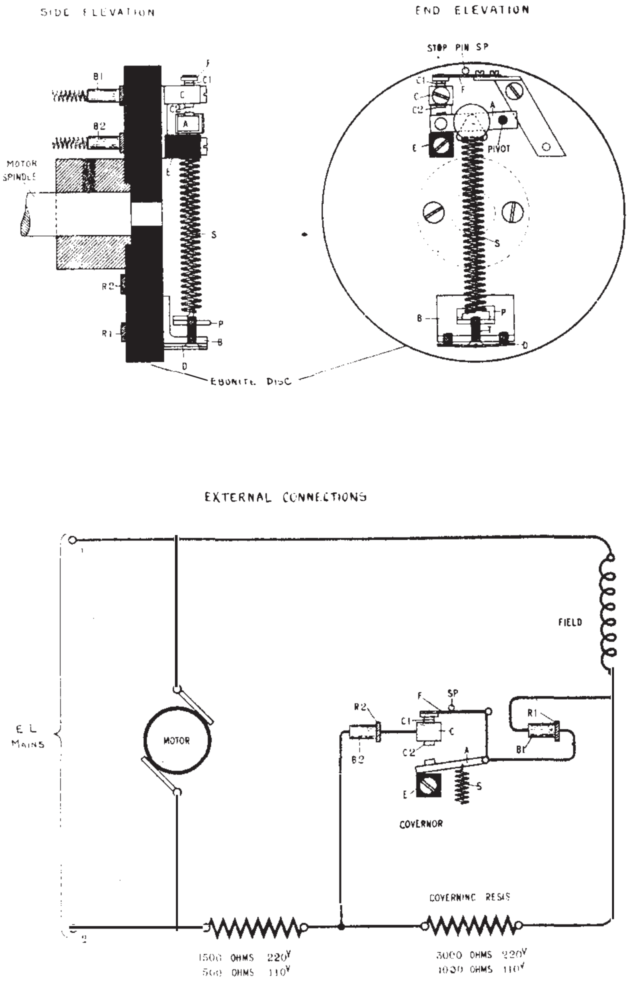


Fig. 12.

there is a Shift Comb (K6 in Figs, **8** and **9**) which can also occupy one of two positions. The blocked-in parts of the various Combs denote projections, and with the Shift Comb in the “ letters ” position shown, the projections on it allow only Primary character latches to be selected when the other five Combs are set. If the Shift Comb is displaced slightly to the left (“ figures ” position), the projections on it move under the Primary latches and allow only the selection of the secondary character latches. For instance, with the Shift Comb in the “ letters ” position, if the incoming combination is 1, 2, 4 spacing, and 3, 5 marking, latch H will be selected, while if the Shift Comb is in the “ figures ” position, latch $^{5}/$ will be selected. Fig. **12** shows the Shift Mechanism. The forked end of the Shift Lever SL engages with a Shift Pin fixed to the Shift Comb. If the distant station sends the Figure Shift combination, which is 1, 2, 4, 5 marking and 3 spacing, the combs 1, 2, 4, 5 move to the left, slightly, and the Figure Shift Latch enters the notches thus aligned and operates SL. The forked end of the latter in acting on the Shift Pin turns the Shift Comb anti-clockwise to the “ figures ” position and all selections following this will give secondary characters. The change back to “ letters ” occurs when the Letter Shift Latch is selected and operates SL.

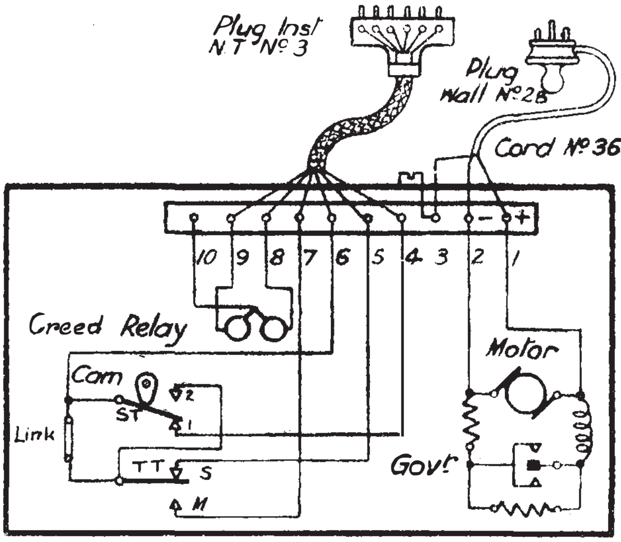


FIG. **13**.

Governor.—The Creed Governor is of the centrifugal type and is fixed on one end of the spindle of the Driving Motor as shown in Fig. **12.** It consists of an ebonite disc on one side of which are mounted the Contact Arms A and F, and the contact block C, etc. On the other side are two brass rings, R1 and R2, upon which ride the carbon brushes, B1 and B2, for making the connections to the motor circuit. The Contact Arm A is controlled by the Spring S and is normally held against the insulated block E, so that the contacts C2 are open. F is a flat spring weighted at its free end and normally closing the contacts C1. A and F are both electrically connected to R1, and the Contact Block C is connected to R2.

When the motor is not running, the Contact Arms rest as shown and F short-circuits the Governing Resistance, thus ensuring a large starting current through the Motor Field Windings. When the Governor commences to rotate, F flies outwards and in opening contacts C1 switches the Governing Resistance into the Field circuit, thus causing the Motor speed to *increase*. A also moves outwards and eventually closes contacts C2; this short-circuits the Governing Resistance, thereby causing the speed to decrease so that A opens the contacts C2, switches in the Governing Resistance and again causes the speed to increase. This making and breaking at C2 takes place very rapidly and an average speed is maintained, depending on the Governing Resistance and the tension of S. The lower end of S is fixed to a plate P which engages with a fine screw T by means of which the tension of S may be altered.

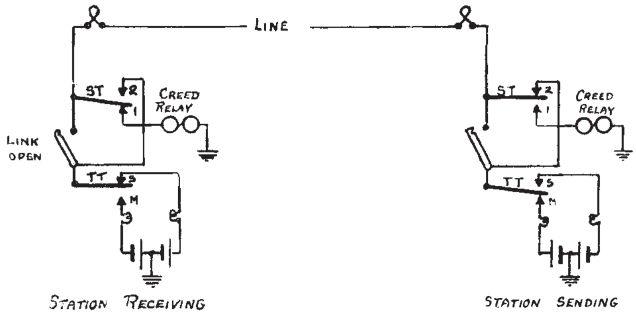


FIG. **14**.

The stroboscopic method of checking the speed is used.

Circuit Connections.—The internal connections of the Teleprinter 3A are shown in Fig. **13.** For Up and Down D.C. Simplex Working, shown diagrammatically in Fig. **14**, use is made of the "Send Receive" switch ST (see also Fig. **5**). The function of this switch is the same as that of the switch on a D.C. key, *i.e.*, it cuts off the battery when receiving and substitutes the reçeiving apparatus. The movement of ST is controlled automatically by a cam on the Transmitting Spindle, and when this spindle is at rest ST is against contact 1, thus joining the Creed Relay direct to the line. As soon as the spindle starts to rotate, the cam allows ST to move over to contact 2, disconnecting the relay and joining the Transmitting Tongue TT to the line. The Link between TT and ST must be opened with this method of working; when it is closed it short-circuits ST.

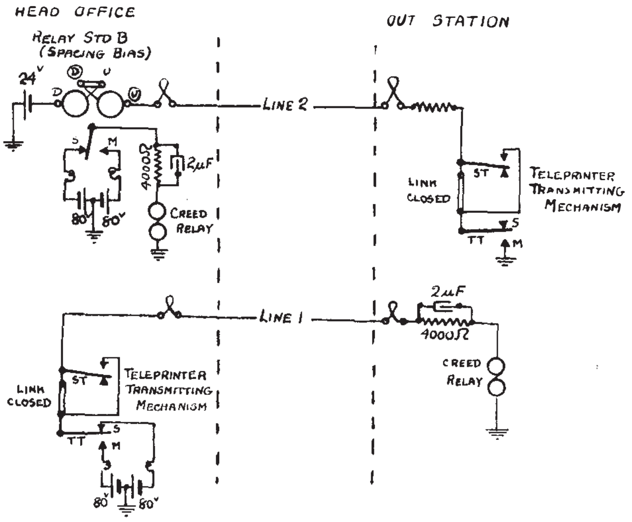


Fig. **15**.

Two Line Simplex working is often used on short routes from a Head Office in order to allow balancing apparatus and batteries to be dispensed with at the Out Station. Fig. **15** shows the arrangement, and it will be seen that the Head Office works double current over Line 1 to the Creed Relay at the Out Station. The latter sends over Line 2 to the Head Office by making and breaking the circuit. The circuit is disconnected while the Transmitting Tongue TT at the Out Station is on the Spacing Contact, and is earthed when it moves to the Marking Contact. The Head Office Relay is set with a "spacing" bias, which is overcome when a line current flows, and the Creed Relay in the local circuit is operated. Only one Teleprinter is used at each office.

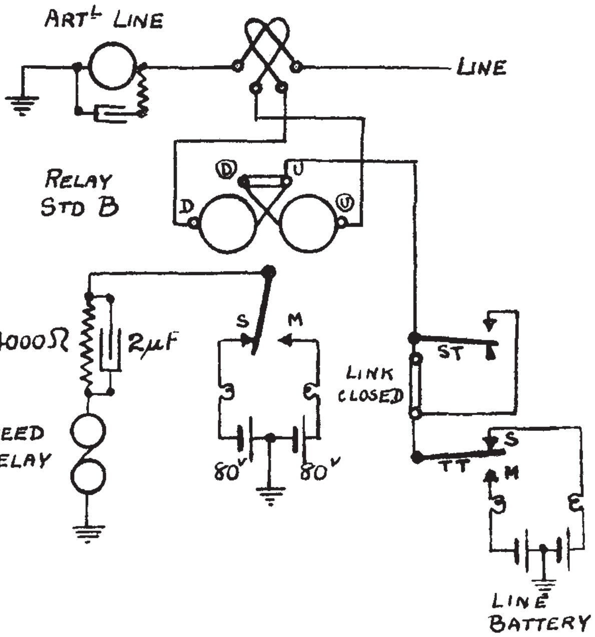


Fig. **16**.

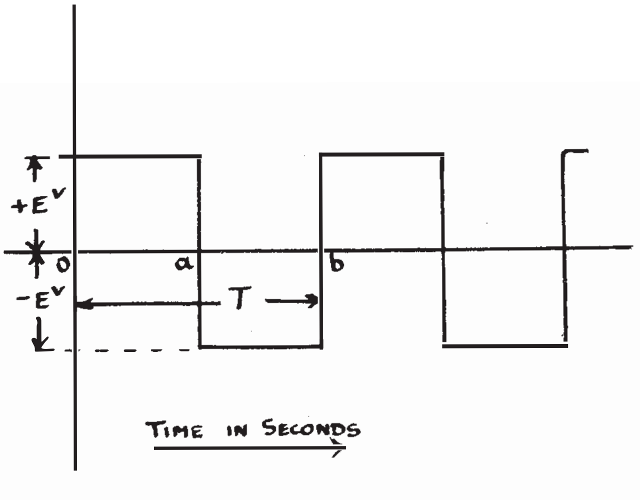
The connections for duplex working are shown in skeleton form in Fig. **16**, and are sufficiently obvious to require no comment. Both stations are joined up alike.

THE END.

TRANSMISSION SPEEDS OF TELEGRAPH APPARATUS.

A. E. Stone, A.R.C.Sc.

On all telegraph lines of any importance double-current working is adopted because of its advantages from a transmission point of view as compared with single current working. These advantages are well known and need not be detailed here. In the double current system the series of "dots" represented in Fig. **1** is formed by applying at the sending end of the line the opposite poles of a battery alternately for equal lengths of time. The time interval from o to *a*, or from *a* to *b*, may be termed a dot unit; the interval from o to *b*, *i.e.*, two dot units, is termed the period, and if it be denoted by T seconds the number of dots that is sent per second, called the "dot" frequency, is given by $f = \frac{1}{T}$. The zig-zag curve of Fig. **1** may be represented by the complex alternating e.m.f.



$$e = \frac{4E}{\pi}\left[\sin 2\pi ft + \tfrac{1}{3}\sin 6\pi ft + \tfrac{1}{5}\sin 10\pi ft + \ldots\ldots\right]$$

where E is the e.m.f. of the sending battery and f is the dot frequency.

In actual signalling, whatever the apparatus used, a regular sequence of dots rarely occurs for any length of time; for instance, in Morse signalling dashes and letter spaces must necessarily be sent at frequent intervals. An approximate idea of the transmission of signals over telegraph lines may be obtained, however, by considering the case of "dot" signals only and, incidentally, it may be mentioned that the transmission problems are simplified by the fact that on long, well-insulated lines worked at high speed only the first term in the complex expression given above, viz., $\sin 2\pi ft$, need be considered, because the currents at the receiving end resulting from the harmonic components $\sin 6\pi ft$, etc., are attenuated to such an exent as to be negligible in comparison with that resulting from the fundamental, $\sin 2\pi ft$.

In dealing with the transmission speeds of telegraph apparatus, there are obvious advantages in considering the rate of signalling as so many cycles per second (*i.e.*, the dot frequency) as against the usual practice of so many words per minute. To state the speed of a circuit in words per minute conveys nothing that is intelligible for transmission purposes unless the type of apparatus used is also stated. For instance, if the maximum working speed of a circuit with Wheatstone Apparatus is 125 words per minute, it could be worked at a speed of approximately 200 words per minute with apparatus using a five-unit code; the vital factor governing the working speed of the apparatus is the maximum permissible number of cycles per second, and this for the example given is 50 for both the Morse and the five-unit code at the quoted speeds.

From a commercial point of view it is desirable of course to know the speed in words per minute, and the following shows the methods of obtaining the speed in cycles per second corresponding to speed in words per minute for the principal types of telegraph apparatus.

(1) *Wheatstone Morse System.*—The Morse code is made up of two elementary signals, which are distinguished from each other by their duration. One signal, called a "dot," is taken as the unit; the other signal, which is called a "dash," is three times as long. Each letter of the alphabet is represented by a particular combination of dots and dashes. The spaces between the elements forming a letter are each

equal in length to one dot, while the spaces between the letters of a word are each equal to three dots, and between words five dots.

The various characters in the Morse code differ widely in length, but on an average may be assumed to be equal to eight dot units. The length of an average word (this is independent of the code used) is taken to be five characters plus one letter space, or six characters, and as the length of the average character is eight dot units, the average word consists of 48 dot units in the Morse code.

Now in sending a series of dots, each marking current, which has a length of one dot unit, is followed by a spacing current of the same length and this combination forms one reversal of current.

Accordingly 48 dot units represents 24 cycles of current, and this is the number of cycles per average word. If W be the speed in words per minute, the number of cycles per minute is 24 W. Hence

$$\text{The Transmission speed} = \frac{24W}{60}$$
$$= 0.4W \textit{ cycles per second.}$$

Thus if the speed W be 125 words per minute, the Transmission speed is .4 × 125 = *50 cycles per second.*

(2) *Duplex Multiplex Type-printing Systems.*—In the five-unit code used with these systems, each character has a length of five dot units and the space between words has the same length.

If S be the number of segments on the sending ring of the distributor and alternate segments are connected to the positive and negative poles of a battery, respectively, it is possible to send $\frac{S}{2}$ cycles of current per revolution of the brush arm. Accordingly if N revolutions per minute be the speed of the brush arm, the number of cycles per minute is equal to $\frac{SN}{2}$. Therefore:

$$\text{The Transmission Speed} = \frac{SN}{2 \times 60}$$
$$= \frac{SN}{120} \text{ cycles per second} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

As previously stated, the length of the average word is six characters. Now, one revolution of the brush arm is necessary for sending one character per channel, hence six revolutions are required for sending six characters, *i.e.,* one word. If, then, the working speed of a channel be W words per minute, $W = \frac{N}{6}$. Substituting the value of N obtained from this in Equation (1) gives:

$$\text{The Transmission Speed} = \frac{S \times 6W}{120}$$
$$= \frac{SW}{20} \text{ cycles per second} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

If c be the number of channels, then in the Baudot System

$$S = 5c + 2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

because each sending channel has five segments, and two additional segments are required for correction purposes.

If, however, correction from signals is used, the two correcting segments are not required and then

$$S = 5c \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Substituting (3) and (4) in (2) gives

Transmission Speed (Baudot System)

$$= \frac{(5c + 2)W}{20} \text{ cycles per second} \ldots\ldots (5)$$

Transmission Speed (Correction from Signals)

$$= \frac{5cW}{20} \text{ cycles per second} \ldots\ldots\ldots\ldots\ldots (6)$$

It will be seen that for a given speed per channel, the transmission speed using correction from signals is less than that for the Baudot System, and the advantage of the former is greater the smaller the number of channels.

By putting c = 4, 3 and 2 in equations (5) and (6) the following formulæ may be obtained for the transmission speeds of Quadruple, Triple and Double Multiplex installations, respectively:—

Installation	Transmission Speed in Cycles per sec.	
	Baudot System	Correction from Signals
Quadruple Duplex	1.1W	W
Triple Duplex	.85W	.75W
Double Duplex	.6W	.5W

From these formulæ the following table has been prepared :—

Installation	Speed per Channel W	Transmission Speed in Cycles per second.		Total Output in Words per Minute (w × c)
		Baudot System	Correction from Signals	
Quadruple ($c=4$)	30	33	30	120
Quadruple ($c=4$)	35	38.5	35	140
Quadruple ($c=4$)	40	44	40	160
Triple ($c=3$)	40	34	30	120
,,	47	39·95	35·25	141
,,	50	42·5	37·5	150
,,	53	45·05	39·75	159
Double ($c=2$)	50	30	25	100
,,	55	33	27·5	110
,,	60	36	30	120

To illustrate the importance of correction from signals, consider the case of a line the maximum working speed of which is 40 cycles per second. Taking triple duplex multiplex installations as an example it would be possible to work—

(1) Triple Baudot at 47 words per minute per channel, giving a total output of 141 words per minute; or

(2) Triple Multiplex (correction from signals) at 53 words per minute per channel, giving a total output of 159 words per minute.

Clearly if both systems were worked at a speed of, say, 45 words per minute, the correction from signals' method would give the wider working margin, because its transmission speed would only be 33·75 cycles per second compared with 38.25 cycles of the Baudot installation. The lower transmission speed of the former would allow of satisfactory duplex working with a less accurate balance than would be demanded by the higher transmission speed of the latter.

The advantage of the five-unit code as compared with the Morse code will be apparent by referring to the following table which shows the respective transmission speeds for a working speed of 120 words per minute :—

Installation.	Total Output Words per Minute	Transmission Speed. Cycles per sec.
Wheatstone.	120	48
Quadruple Duplex (*a*) (Baudot System)	120	33
Quadruple Duplex (*b*) (Correction from Sigs.)	120	30
Triple Duplex (*c*) (Baudot System)	120	34
Triple Duplex (*d*) (Correction from Sigs.)	120	30

(3) *Teleprinter Systems.*—Teleprinters use a five-unit code for the actual character combinations, but employ in addition a start signal of length one unit and a stop signal of length $1\frac{1}{2}$ units, so that from a transmission point of view each character has a length of $7\frac{1}{2}$ units, *i.e.*, $3\frac{3}{4}$ cycles.

If t secs. be the time of one revolution of the Transmitting Cam spindle, then in this period of time $3\frac{3}{4}$ cycles can be sent. Hence :

$$\text{The Transmission Speed} = \frac{3\frac{3}{4}}{t} = \frac{15}{4t} \text{ cycles}$$

per second.

For the Teleprinter 1A, which has a maximum operating speed of 40 words per minute, $t = .25$ second.

$$\therefore \text{ The Transmission Speed} = \frac{15}{4 \times .25} = 15$$

cycles per sec.

In the Teleprinters 2A and 3A, each of which has a maximum operating speed of 60 words per minute, t = .154 second, hence :

$$\text{The Transmission Speed} = \frac{15}{4 \times .154} = 24.4$$

cycles per sec.

It is interesting to note in connection with the latter that Wheatstone working at 60 words per minute is equivalent to a transmission speed of 24 cycles per second; hence from a transmission point of view the Teleprinters 2A and 3A are slightly worse than Wheatstone working at an equivalent speed.

TELEPHONES

WESTERN EXCHANGE, LONDON.

F. P. Dumjohn, A.M.I.E.E.

Western Automatic Exchange, forming another link in the " Director " network of London, was successfully brought into service at 4 p.m. on Saturday, January 5th last, and the old C.B. manual equipment cut out of service. The time chosen for the change-over certainly has its advantages judging by the views of those present who had past experience of midnight transfers.

The excellent work done by the Department's officers in organising and preparing all " preliminaries " was markedly exemplified in the fault returns available after the " all-clear " of the old exchange was reported. The analysis of these showed less than 1% P.Gs., six subscribers' apparatus faults, no junction faults and four switching equipment faults. The latter favourable result may be justifiably credited to

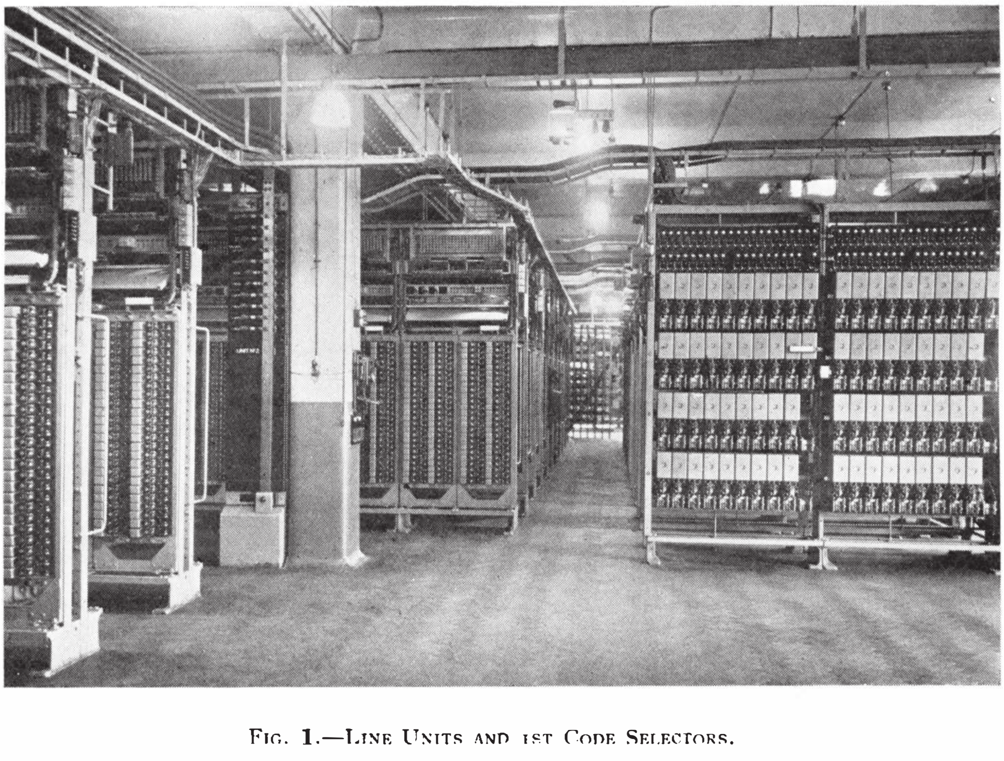


Fig. 1.—Line Units and 1st Code Selectors.

the Contractors, Messrs. Siemens Brothers & Co., Ltd., of Woolwich, and, as this is the first London exchange to be supplied by this firm in the London auto network, a brief review of some of its features may be of interest.

The initial equipment provides for 7,100 lines (preselectors), 7,400 multiple numbers and 300 auxiliary numbers for P.B.X. groups exceeding 11 lines. Switch equipment is provided for 6,800 lines and spare banks enable additional circuits to be fitted to serve for the 7,100 working lines.

Although the exchange serves the busy shopping district of Kensington, its traffic load is relatively light in comparison with Metropolitan exchanges. The originating traffic for which provision is made is about an average of 0.036 traffic units per line, whereas densities of about 0.7 to 0.9 and more occur in Meropolitan exchanges. There are 388 First Code Selectors for originating subscribers' traffic and only a little over 10% of the traffic is between WES subscribers, routed from level " 0 " to 64 First Numerical Selectors. Part of the outgoing traffic is routed direct from four levels of the First Code Selectors and the remainder *via* 352 Second Code Selectors. Incoming traffic from the Trunk Exchange, Automatic and Manual Exchanges, is completed over 591 Junctions passing through a 11-position Cordless " B " Board to First Numerical Selectors.

All Manual Services, comprising assistance " 0 " calls, Information, Service P.B.X., Interception and Supervisors, are dealt with at a 20-position Manual " A " Board. Trunk calls to subscribers found engaged at the Cordless " B " Board are transferred and completed at the Manual " A " Board.

There are 71 Line Units, each fully equipped for 100 preselectors, but only two have the full equipment of 32 final selector banks. The remaining 69 are partially equipped with 16 final selector banks. Separate Test and Trunk Offering switches are provided to which access is obtained from 8 Test Distributors and 6 T.O. Distributors respectively. The Line Units (Fig. 2) differ in design from those in London Exchanges already in operation, principally in the mounting of the preselectors. These are mounted horizontally and arranged in four vertical panels of 25 divided on two gates. The multiple on the banks is neatly splayed out so as to facilitate access to the soldered joints on the bank contacts. The terminal assembly at the top provides for separate terminals for the preselector arms and the final selector multiple so as to enable multiple numbers to be cross-connected with the minimum of limitation to particular preselectors. A run for jumper wires for this purpose is arranged between line units.

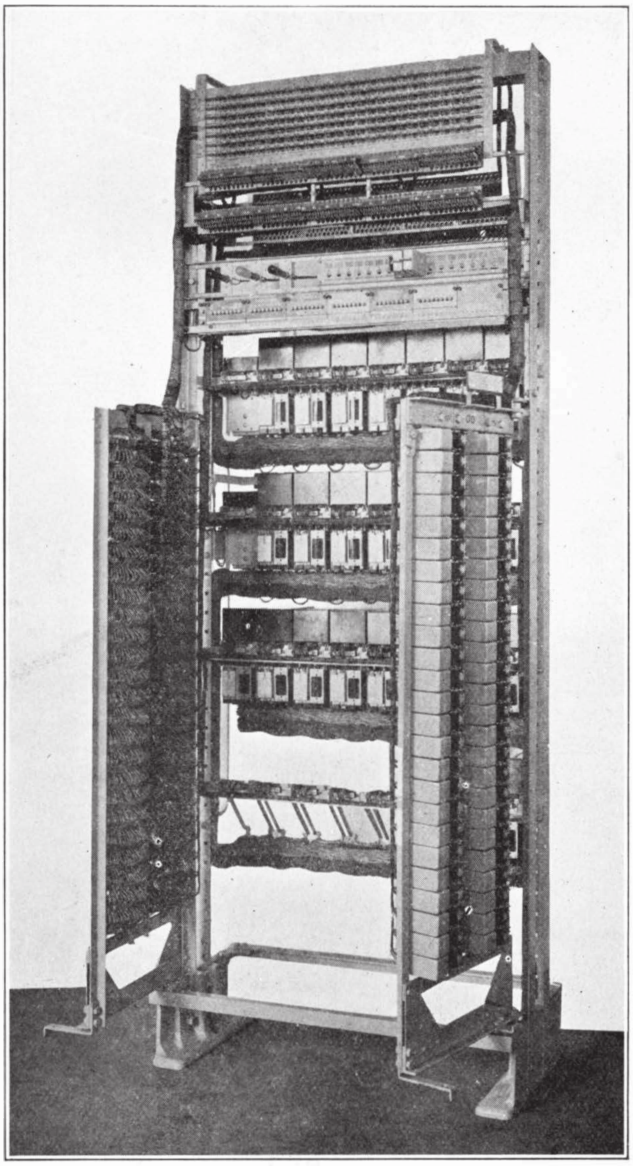


FIG. 2.—LINE UNIT.

There are 65 " A " digit selectors with the usual grouping arrangements to 111 Directors. Each Director is a self-contained unit arranged

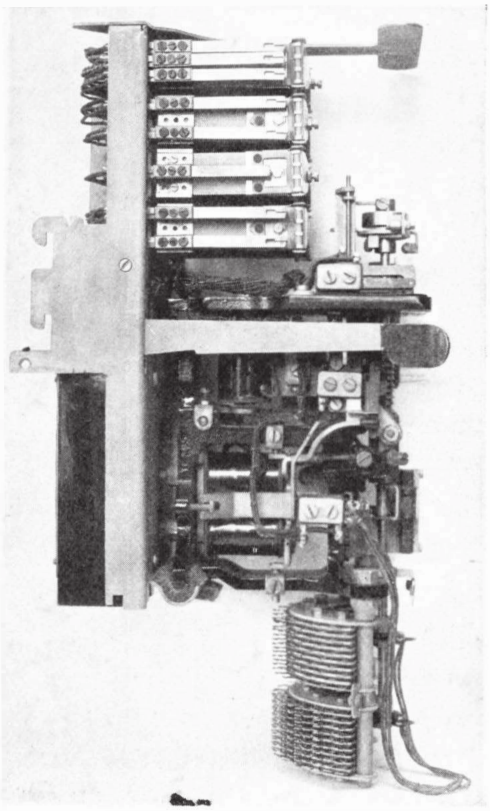


Fig. 3.—" A " Digit Selector
Showing Lever Arm raised to " disconnect " position.

for jacking-in, but in view of the weight of such a unit consideration is now being given to separating it into two units so as to facilitate easy removal.

The selectors are mounted on racks arranged in U formation with a terminal assembly at one end as in other London Exchanges. The selector mechanism and associated relays for each type of selector are mounted on one plate, with jacking-in points and wired complete as a "Circuit Unit." (Fig. **3**). The advantages of this unit arrangement are well-known, but it may be as well to stress one in particular, namely, the interchangeability of selector units wherever the external panel and rack wiring can be so arranged.

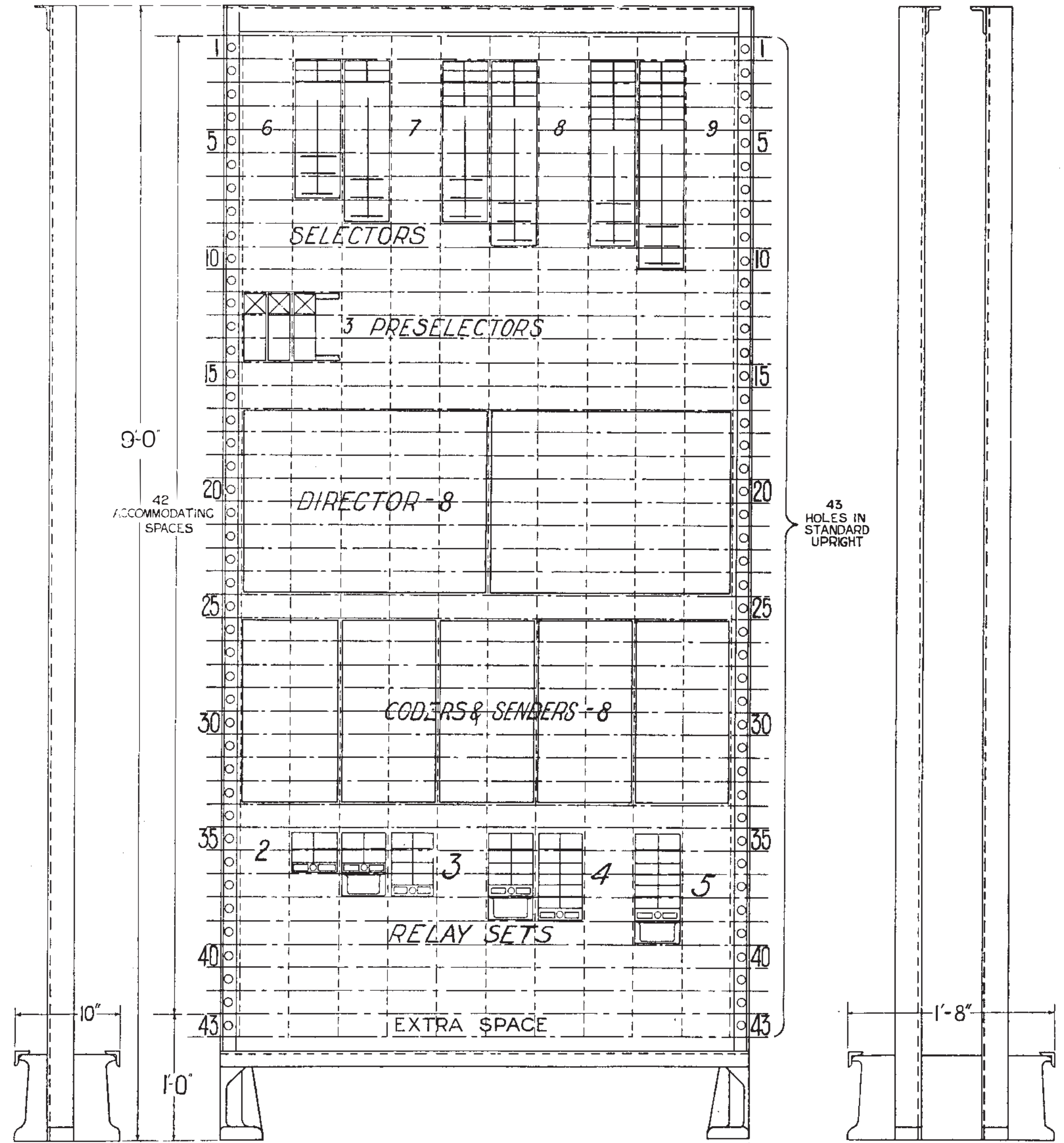
A feature on the selector units is a lever connected with the contact blades, by means of which the contact blades can be lifted from their sockets, so that by raising the lever a faulty unit can be disconnected, or isolated from battery potentials before making adjustments. The end of the lever is painted red and in the " disconnect " position it is readily seen projecting from the switch.

The method adopted for the suspension of

Fig. **4**.—Single Member Suspension.

selector and relay set units is an innovation which claims attention. All sizes of units are suspended on a single angle iron member (Fig. **4**) between the uprights of a rack. Stamped metal cradles with two pairs of projecting ears are fixed to the angle iron, having the ears arranged to engage with slots on either side of the unit mounting plate.

Fig. **5**. DIAGRAM OF UNIVERSAL RACKS



A universal design of rack (Fig. **5**) has been provided, akin to a "Meccano" design, in which all uprights are drilled with holes at such centres as to permit one type of rack to be utilised for any type of apparatus units. It not only facilitates economy in manufacture, but has obvious advantages in facilitating re-arrangements in the exchange.

Three types of P.B.X. final selectors are fitted to provide for groups of 2-10 lines, 11-20 lines and groups over 20 lines. The 2-10 P.B.X. groups provide the same facilities and features as those originally introduced in Messrs. Siemens Brothers' No. 16 Auto Equipment and enable ordinary lines to be connected to any number not reserved for a P.B.X. line. The 11-20 groups provide for P.B.X. lines only of this size and have the same operating conditions as in other London Exchanges. The "over 20" type, although embodying the basic principles of the 11-20 type (with which it has been designed to be interchangeable), has special features of its own. It is fitted with a 200-point bank and any number of P.B.X. groups of lines can be connected from 10 of 20 up to 1 of 200 lines. The banks of the 11-20 and over 20 P.B.X. groups are cabled to the Manual I.D.F., where they are cross-connected to tie-cable circuits to the Line Units on which the associated preselectors are mounted, the facilities being such that about 5% of the preselectors on each line unit are assigned for P.B.X. lines.

Improvements have been made in circuit design, *e.g.,* a rotary magnet make contact is employed for the drive of selectors, delayed metering is used so that no lock-up contact on subscribers' meters is required and the way is prepared for the ready introduction of multi-metering. Space does not permit of enumerating other features except the one particular economy made in the number of relays used in earlier circuits, *e.g.*:—

Group Selectors have 4 relays instead of 5
Ordinary Finals ,, 7 ,, ,, ,, 8
2-10 P.B.X. ,, ,, 8 ,, ,, ,, 9

Automatic routiners are fitted for testing First Code Selectors, Coders, Senders, Directors, C.C.I. Repeaters and "B" Position Junction Relay Sets.

Duplicate batteries of 25 cells are provided, plated for 3,930 and box capacity for 5,502 amp. hours and are designed for 24 hours exchange consumption. A set of 11 C.E.M.F. cells provides for 30 volt P.B.X. power leads, but C.E.M.F. cells for regulating the exchange busbar voltage are not fitted. Duplicate motor-generators of 51 K.W. output serve either for operating the plant on a charge-discharge basis or with either battery floating. The power circuit provides for single pole switching as now standardised by the Department, and the simplifications thereby effected are noticeably apparent in the size of the power board, which measures only 8 feet in length, including the ringer panel.

The ringing machines and interrupters are in duplicate, one driven from the public supply and the other from the battery. Whilst the mains driven ringer is in use, arrangements provide for its disconnection on failing from any cause to switch in the battery ringer automatically.

The writer is indebted to the Engineer-in-Chief of the Post Office for permission to publish this brief outline and to the courtesy of the Board of Editors for its publication.

RELAY AUTOMATIC SYSTEM IN CZECHO SLOVAKIA.

R. MORDIN.

THE Great War destroyed many things and created some others, among them the Republic of Czecho Slovakia, having a population of about 14 millions and an area about equal to that of England and Wales.

By the end of the War, the people of Bohemia, Moravia and Slovakia had been brought to the verge of starvation. Thanks, however, to the statesmanship of Dr. Masaryk and Dr. Benes exerted at the Versailles Peace Conference, the State of Czecho Slovakia, combining the three countries mentioned, was constituted and recognised by the Allied Powers. By 1921 it had become one of the most stable and prosperous territories in Europe exhibiting a phenomenon at that time unique in Central Europe, to wit, a balanced Budget. Since then the country has developed progressively and on account of its natural resources bids fair to become one of the most important industrial areas in Central Europe.

Czecho Slovakia has not been slow in recognising the benefits of Automatic Telephone Service, and an interesting Relay Automatic Public Exchange network has recently been brought to completion at Moravska Ostrava, perhaps its most important industrial city.

The various exchange equipments were designed by the Engineers of the Relay Automatic Telephone Company to the specification of the

Department of Posts and Telegraphs, C.S.R., and the equipment was manufactured under licence from the Company by the firm " Telegrafia," of Prague, who also carried out the work of installation under supervision by the Relay Company's engineers.

The network is illustrated diagramatically by Fig. **1**, and consists of a main exchange initially equipped for 2,500 subscribers' lines, to which are connected six automatic satellites. A number of manual exchanges are also provided with junction service through the main exchange, whose design provides for the gradual conversion of the manual satellites to automatic working in the future.

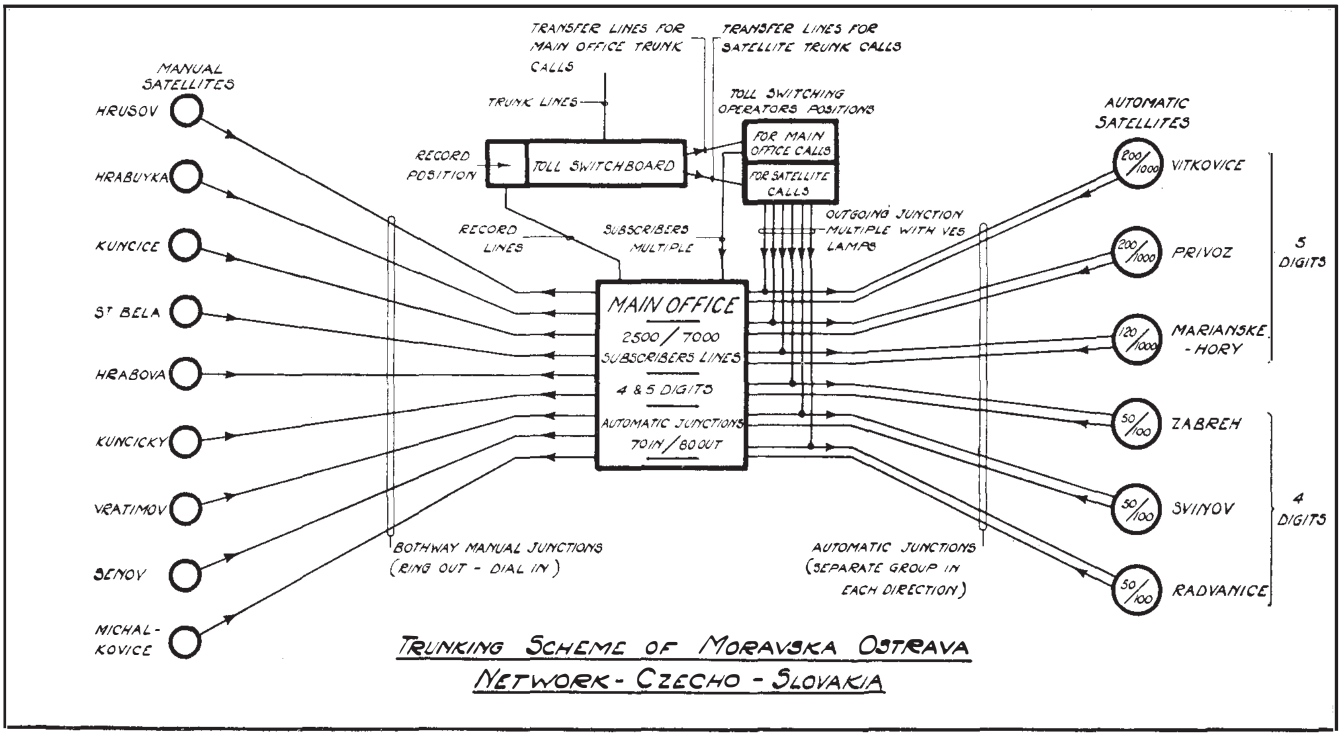

TRANSFER LINES FOR MAIN OFFICE TRUNK CALLS
TRANSFER LINES FOR SATELLITE TRUNK CALLS
MANUAL SATELLITES
TRUNK LINES
TOLL SWITCHING OPERATORS POSITIONS
AUTOMATIC SATELLITES
HRUSOV
RECORD POSITION
TOLL SWITCHBOARD
FOR MAIN OFFICE CALLS
FOR SATELLITE CALLS
200/1000
VITKOVICE
HRABUYKA
RECORD LINES
SUBSCRIBERS MULTIPLE
OUTGOING JUNCTION MULTIPLE WITH VES LAMPS
200/1000
PRIVOZ
5 DIGITS
KUNCICE
MAIN OFFICE
2500/7000 SUBSCRIBERS LINES
4 & 5 DIGITS
AUTOMATIC JUNCTIONS 70 IN/80 OUT
ST BELA
120/1000
MARIANSKE-HORY
HRABOVA
50/100
ZABREH
KUNCICKY
VRATIMOV
50/100
SVINOV
4 DIGITS
SENOV
BOTHWAY MANUAL JUNCTIONS (RING OUT - DIAL IN)
AUTOMATIC JUNCTIONS (SEPARATE GROUP IN EACH DIRECTION)
50/100
RADVANICE
MICHALKOVICE
TRUNKING SCHEME OF MORAVSKA OSTRAVA NETWORK - CZECHO - SLOVAKIA

FIG. **1**.

The number of lines to be connected ultimately to the main office remains indeterminate, and is only limited by the floor space that can be made available in the future. The ultimate equipment will certainly reach 7,000 lines, and may be expected to extend beyond that figure. The layout of the equipment in the main office is shown in Fig. **2**.

General Characteristics.—All selecting and connecting operations are performed by relays precisely similar to those employed in the well-known P.A.B.X switchboards supplied by the Relay Automatic Telephone Company to the British Post Office, and have in all cases the following characteristics:—

	Minimum.	*Normal.*	*Maximum.*
Armature Stroke ...	28	30	32 mils.
Contact Pressure— " make " contacts ...	$1\frac{3}{4}$	$2\frac{1}{8}$	$2\frac{1}{2}$ ozs.
Contact Pressure— " break " contacts...	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$ ozs.

The gap in the magnetic circuit when relays are operated is fixed precisely at 2, 6, 12, or 24 mils, depending on the function of the relay.

It is of interest that the Main Office contains 21 relays per line based upon the initial equipment of 2,500 subscribers' lines and 150 junctions, a figure only very slightly in excess of the relays per line in small P.A.X.'s and P.A.B.X.'s.

Numbering Scheme and General Operation.—The numbering scheme of the network is as follows:—

	1	Not used. Equipment rejects " 1 " as a false impulse.
Main Office	2,000 etc. 3,000 etc. 4,000-4499	Initial equipment 2,500 subscribers' lines.
	4,500 etc. 5,000 etc. 6,000 etc. 71,000 etc. — 70,000 etc.	Initially dead levels available for extensions. (Maximum 15,000 subscribers' lines.)

Special Services.

Trunk Record	04	Other " 0 " two figure numbers available for further special services.
Enquiries ...	00	
Telegrams ...	08	

The Main Office equipment consists of two " Subscribers' Divisions," each containing equipment for 950 lines, one " Subscribers' Division " with equipment for 600 lines, and a " Junction Division " dealing with the traffic to and from the automatic satellites as shown in the Floor Plan, Fig. **2**.

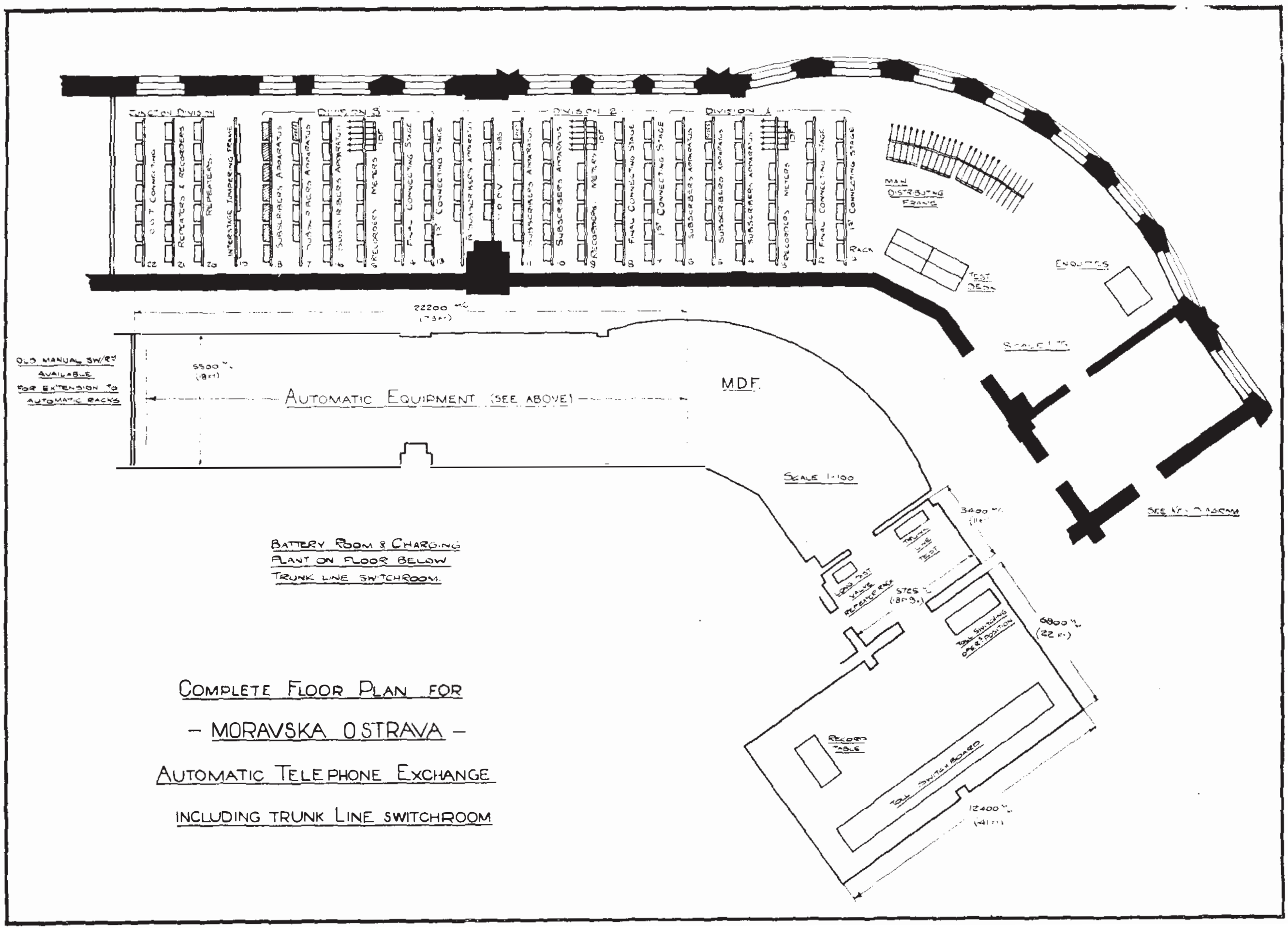


Fig. **2**.

Automatic Satellite Subscribers.

Vitkovice	82,000 etc.	Automatic satellites initially installed.
Mar. Hory	83,000 ,,	
Radvanice	84,000 ,,	Remaining " 8 " and " 9 " five figure numbers available for further automatic satellites.
Zabreh	85,000 ,,	
Svinov	86,000 ,,	
Privoz	97,000 ,,	

A " Subscribers' Division " includes its own IDF and is capable of accommodating 1,000 lines, but on account of ceased services, removals, numbers in reserve for additional P.B.X. lines and other contingencies incidental to public exchange service in general, the whole of the 1,000 numbers would never be simultaneously in use. On this account, and since the

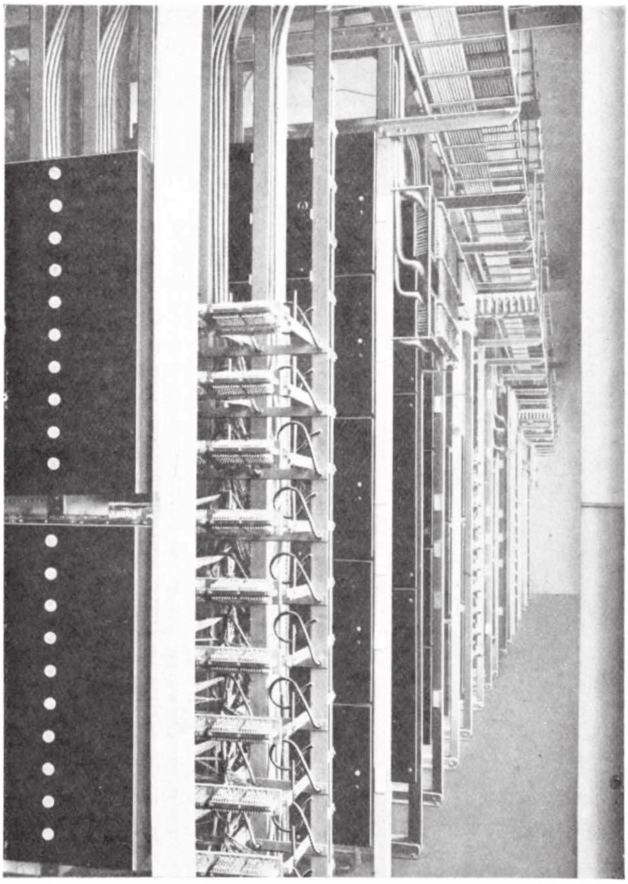


FIG. 3.—VIEW DOWN CORRIDOR FROM INTERMEDIATE DISTRIBUTING FRAME, SUBSCRIBERS' DIVISION 11.
(Rack 9 of Floor Plan).

" Relay " System normally provides that the full range of 1,000 numbers is always available, the actual equipment per " Subscribers' Division " at Moravska Ostrava is reduced to 950 lines in order to avoid waste.

Apart from the apparatus individual to subscribers' lines, each " Subscribers' Division " contains a First Connecting Stage for distributing the originating traffic and a Final Connecting Stage for connecting the terminating traffic for the whole of the lines in the Division.

The trunking stages are of the usual " Trunk Line " type employed in the Relay System* and are controlled by a group of selective circuits (Recorders) associated with each.

Referring to the numbering scheme given above, the First Stage Recorders only accept the first digit dialled (except when the latter is " 7 " when a further digit is accepted) and then cause the call to be extended through the First Connecting Stage into the Final Connecting Stage of the Division in which the required line is located, the final three digits being accepted by the Recorders in the latter and resulting in the desired connection.

In the case of calls for Satellite Subscribers, the first digit dialled (8 or 9) extends the call into an Outgoing Junction Connecting Stage located in the Junction Division in which the Recorders accept the 2nd digit and extend the call to a particular satellite, leaving three digits to be dialled into the Recorders therein for the purpose of finding the required line.

The Satellite Subscribers are connected to a

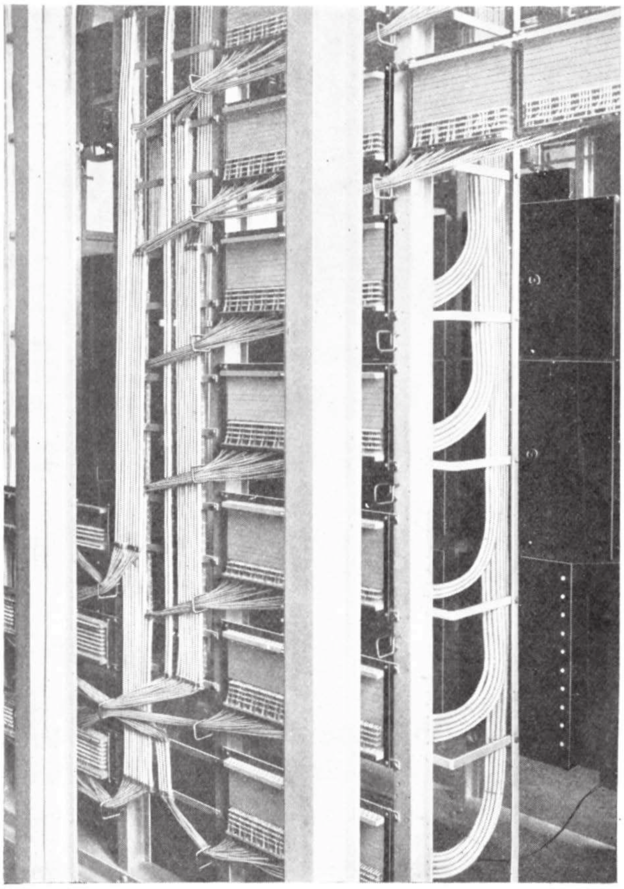


FIG. 4.—DISTRIBUTION OF TRUNKS FROM FIRST CONNECTING STAGES AND REPEATER CONNECTING STAGE TO FINAL CONNECTING STAGES, AND OUTGOING JUNCTION CONNECTING STAGE.
(Rack 19 of Floor Plan).

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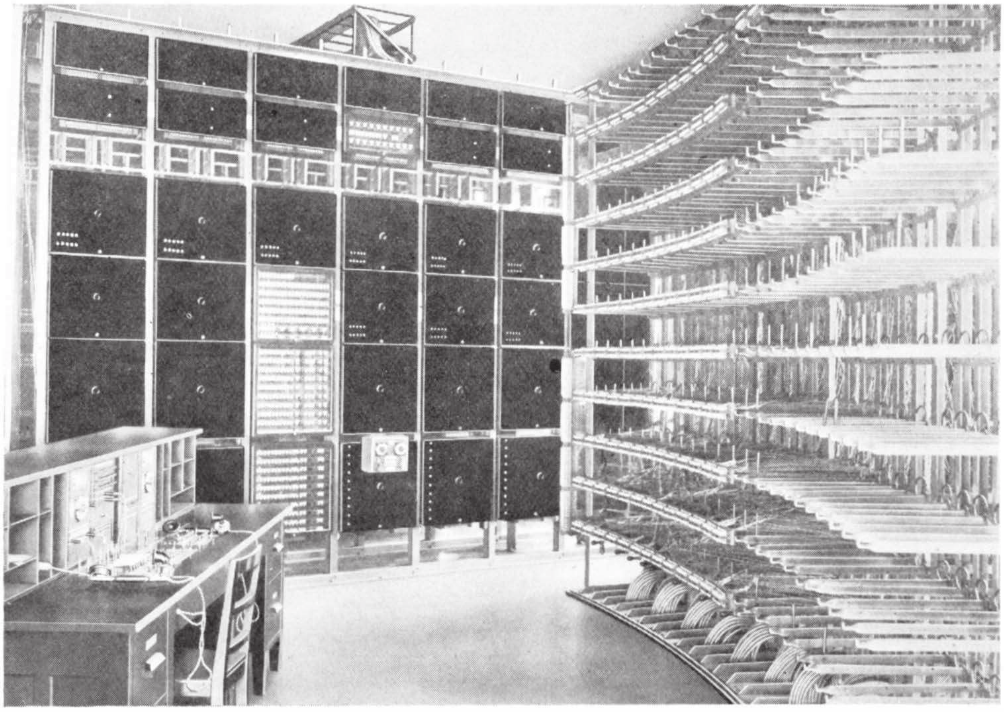
* *See P.O.E.E.J., Vol. 13, Part 1, and Vol. 15, Part 4, and also " The Relay System of Automatic Switching " by H. W. Dipple (Paper read before I. of P.O.E.E.)*

Repeater in the Main Office immediately on taking off their receivers. The Connecting Stage and Recorders associated with the Repeaters distribute the incoming Satellite traffic to the Final Stages of the " Subscribers' Division " and to the Outgoing Junction Connecting Stage (for through traffic), so that the function of the Repeater Connecting Stage resembles that of the First Stages in the " Subscribers' Division," with the exception that if the first two digits dialled by the Satellite Subscriber determine the call to be one local to the satellite, the junction is dropped and, for the first time, a Recorder is brought into circuit at the Satellite, which accepts the final three digits and finds the required line therein.



TEST DESK. FIG. 5. MAIN DISTRIBUTING FRAME.
Rack 1. A & B Feeds and First Connecting Stage, Subscribers' Division 1.
(Covers removed from 4 Relay Groups).

General Facilities.—The following general facilities characterise the automatic equipment:

(*a*) Dialling, Busyback and Number Unobtainable tones in accordance with British Post Office practice.

(*b*) The calling subscriber controls the connection, but in all cases a thermostatic back-release and alarm is provided in the event of slow clearing by the calling subscriber.

(*c*) Line faults and subscriber's irregularities are prevented from engaging common apparatus for more than one minute.

(*d*) Ineffective calls do not occupy trunks in connecting stages or junctions between exchanges.

(*e*) The correct operation of subscribers' meters is automatically supervised. Failure of the meter causes the connection to be held up and an alarm given.

(*f*) The " Search " for an idle trunk or junction is practically simultaneous and extends over the whole group of circuits concerned, without regard to their number.

(*g*) No restriction in the number or distribution of lines constituting a P.B.X. Group.

Trunk Traffic.—Moravska Ostrava was already an important trunk line centre before the introduction of automatic working, and the conditions specified for the operation of the trunk traffic were somewhat exacting.

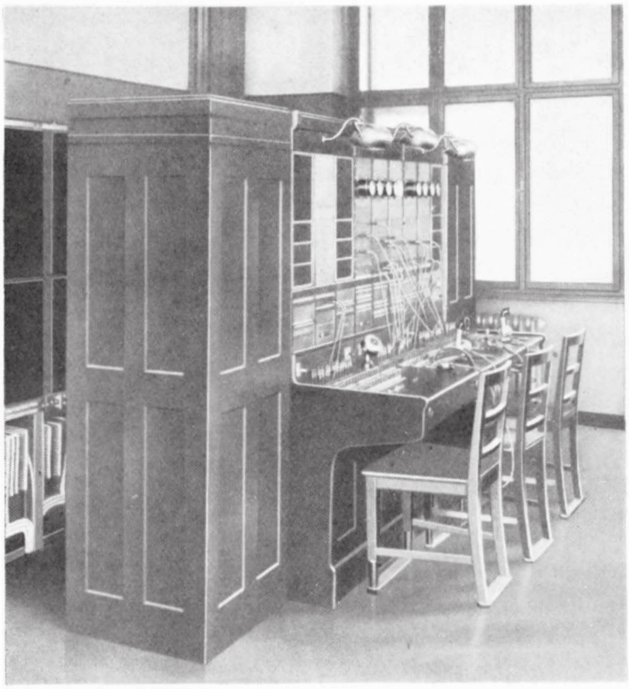


FIG. **6.**—TOLL SWITCHING OPERATORS' POSITIONS FOR ROUTING TRAFFIC BETWEEN ALL AUTOMATIC SUBSCRIBERS IN NETWORK AND THE TOLL SWITCHBOARD PROPER.

It was required, and it has been provided under the new system, that the operators on the existing Toll Switchboard should

(*a*) be given direct access to every automatic subscriber in the network;

(*b*) be able to enter any engaged subscriber's line for the purpose of offering a trunk call;

(*c*) be able to effect the trunk connection over the same circuit by which it was offered, at the same time breaking down any other connection on which the subscriber may have been engaged at the time.

(*d*) For the purpose of the above facilities, in connection with satellite subscribers, the Toll operator should be able to use the ordinary outgoing junctions to the satellites and appropriate any junction if they should all happen to be engaged.

(*e*) In the latter case be able to discriminate before appropriating a junction between those engaged on trunk and ordinary traffic in order not to interfere with existing trunk calls.

(*f*) Positive lamp supervision is to be given to the Toll Operator.

In order to give effect to these arrangements a small manual switchboard for "Toll Switching," as shown in Figs. **2** and **6** and a Record Table, was installed in proximity to the existing Toll Switchboard.

The Main Office subscribers' lines and also the outgoing junctions to the automatic satellites are multipled before the Toll Switching Operators, who are provided with two groups of plug-ended lines from the Toll Switchboard proper,

(*a*) for trunk calls to Main Office subscribers and

(*b*) for trunk calls to Automatic Satellite subscribers.

The routing of the traffic is indicated by the arrows in Fig. **1**.

To effect a trunk call the automatic subscribers dial 04 and details are taken by the Record Operator.

When the call matures it is reverted to the originating subscriber by the Toll Operator through the medium of the Toll Switching Operator, who completes the connection either through the Main Office Subscribers' Multiple or by dialling out over an outgoing junction to a Satellite subscriber.

In the latter case the operator puts out a discriminatory condition when plugging into the junction and when dialling she omits the first two digits of the number. Connection is obtained to the required line whether it is engaged or not, without requiring any special operation by the Toll Switching Operator. Engaged lamps are provided on the O.G.J. multiple and junctions engaged on Trunk Calls have in addition a tone on the sleeve of the jacks in order to comply with condition (*e*) referred to above.

The sole function of the Toll Switching Operator is to obtain connection to the line on behalf of the Toll Operator proper, who afterwards takes complete control of the call. The operation of a trunk call by the Toll Operator is precisely the same for calls to Main Office or Satellite subscribers.

AUTOMATIC ROUTINE TESTERS FOR AUTOMATIC TELEPHONE EXCHANGES.

W. E. Chinn, A.M.I.E.E., and J. S. Young.

IT is unnecessary to stress the important bearing that high grade maintenance has upon the efficiency of the telephone service and routine testing is one of the essential operations. In manual exchanges, faults that occur between routine tests are not allowed to affect the service because the presence of an operator ensures the discovery of the faults and the consequent diversion of traffic to other channels. In an automatic exchange, however, the human element is to a great extent replaced by mechanical switching devices which necessarily have but a limited ability to discriminate between normal and abnormal conditions.

It follows therefore that service could be seriously degraded by the continuance for long periods of undiscovered faults on automatic systems. To avoid this state of affairs, as far as possible, and to obtain early advice of the existence of faults, it is necessary to carry out exhaustive routine tests at comparatively frequent intervals: on the apparatus used in automatic exchanges.

The methods of routine testing employed vary in accordance with the requirements of particular exchanges and are divided under two heads, as follows:—

(1) Manual Testing involving the constant attendance of maintenance officers for the manipulation of the manual and semi-automatic testers employed and for the purpose of associating them with the apparatus to be tested. This method is used extensively in exchanges where only small numbers of each type of apparatus are involved.

(2) Automatic Testing which normally requires attention only when a fault has been discovered in any piece of apparatus under test. This method is used where, owing to the large numbers of each item of apparatus or the complexity of the tests required, it would be uneconomical to employ manual methods.

It is intended in this series of articles to deal with the routine testers which are included under heading 2, giving a general description of the functions applying to all routiners and of certain individual circuit features which are considered to be of special interest.

The routiners to be described are those at present installed in the earlier London Exchanges and, if space permits, others for which access equipment has been, or is being, provided.

Those routiners fitted as part of the main installation are designed for testing the following apparatus:—

(1) Subscriber's and Incoming 1st Code Selectors.
(2) Directors.
(3) C.C.I. Repeaters.
(4) C.C.I. Coders.
(5) Senders.
(6) Keysending "B" Position Apparatus.

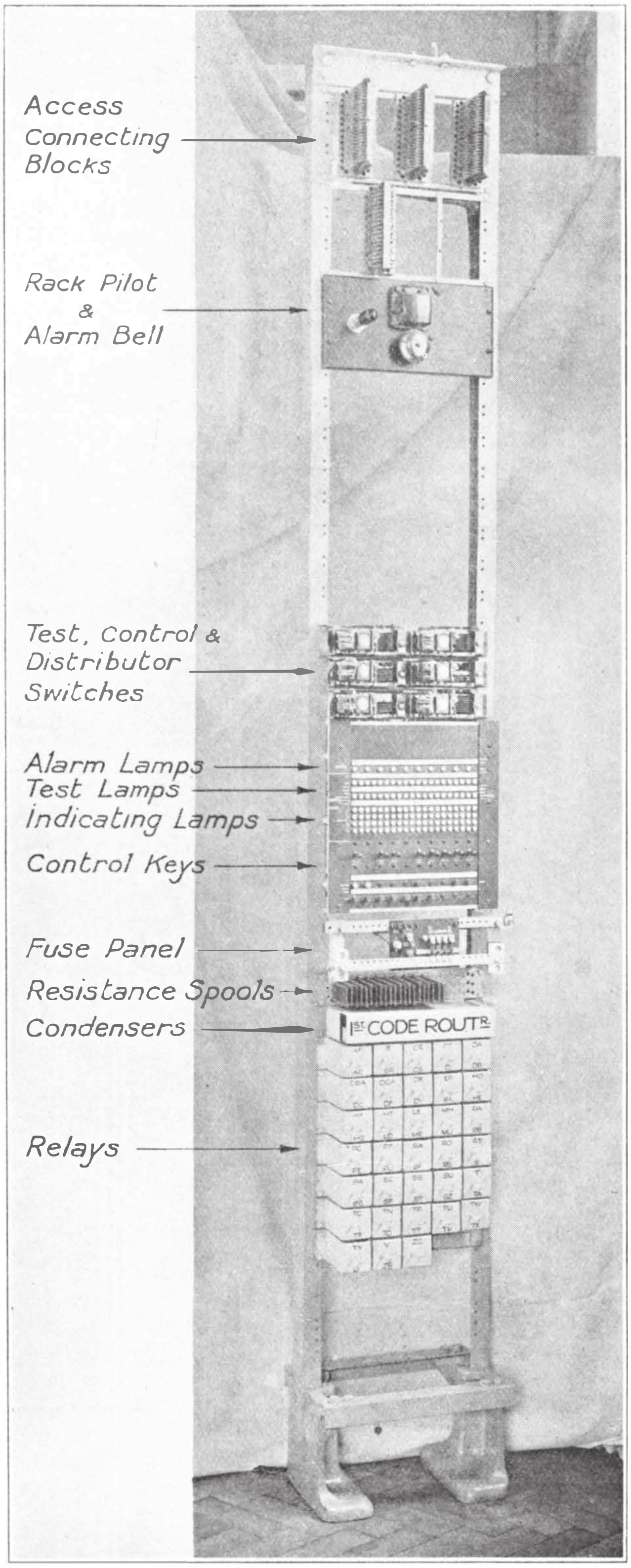
Three other routiner circuits have been designed and are undergoing circuit laboratory trials. These are for testing:—

(1) 11-20 line P.B.X. Final Selectors.
(2) Large Group P.B.X. ,, ,,
(3) C.C.I. Junctions.

Routiners are composed of two main parts: the test and control apparatus, and the access equipment.

The test and control apparatus is generally mounted on a special rack located near the equipment it is intended to test and consists of switches, relays and keys for controlling the sequence of tests to be applied and for changing the circuit conditions as required.

The access equipment consists of a primary distributor (in a few exceptional cases there are also secondary distributors) and access switches. The latter are in most cases mounted with the apparatus to which they afford access, while the former are mounted on the routiner rack. Generally, only 20 contacts of the access switch bank are used; this is in order to give a better numbering and cabling scheme.



1st Code Selector Routiner.

The functions which are common to most routiners are summarised as follows:—

(1) Afford, in cyclic order, access to the apparatus to be tested, as shown in Fig. 1.

(2) Step over contacts of the access switch associated with unequipped apparatus. The stepping is effected in various ways. In some cases by self-interrupted drive; in others by a relay connected to the unequipped contacts, which provides an additional step to the access switch and delays progress of the routiner tests during the stepping; and in other cases by a battery connected to the unequipped contacts to operate a relay in the routiner which is switched into circuit for a given period.

(3) Step over contacts of the primary distributor when no equipped apparatus is connected to the access switch. This is effected as mentioned in (2).

(4) Step the access switch after satisfactory completion of the cycle of tests on one set of apparatus.

(5) Step the primary distributor to the next equipped access switch when all the apparatus associated with the previous access switch has been tested.

(6) Effect stepping of the access equipment manually by means of push type keys to any required set of apparatus for the purpose of continuously routining same.

(7) Routine test continuously any required set of apparatus and ensure adequate guarding of same between the test cycles. A key designated "Continuous Routine" is provided for the purpose of disconnecting the normal access equipment stepping circuits, thereby causing the tests to be repeated on the same set of apparatus.

(8) Afford indication, by means of lamps on the routiner rack, which set of apparatus is being tested. In some cases an individual lamp is associated with each set of apparatus to be tested; in other cases shelf lamps with a common set of access switch lamps are provided; and in the remaining cases one set of lamps and a lamp indicating key are

provided, the key being employed for the purpose of associating the lamps with the access switches or the primary distributors as required.

(9) Afford lamp indication of the particular test in progress. These lamps also afford indication of the test which failed when a fault is encountered. One level of the test switch, where fitted, has its relevant bank contacts connected to these lamps. Where a test switch is not fitted, contacts of the relays controlling the test are used.

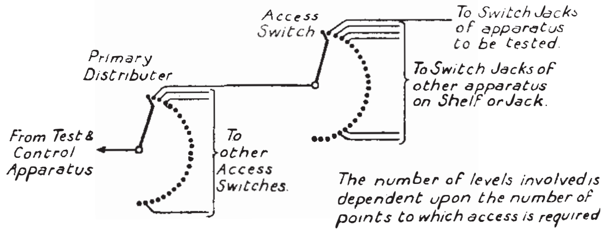

Access Switch
To Switch Jacks of apparatus to be tested.
Primary Distributer
To Switch Jacks of other apparatus on Shelf or Jack.
From Test & Control Apparatus
To other Access Switches.
The number of levels involved is dependent upon the number of points to which access is required

FIG. 1.

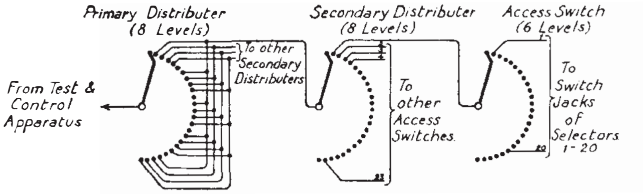
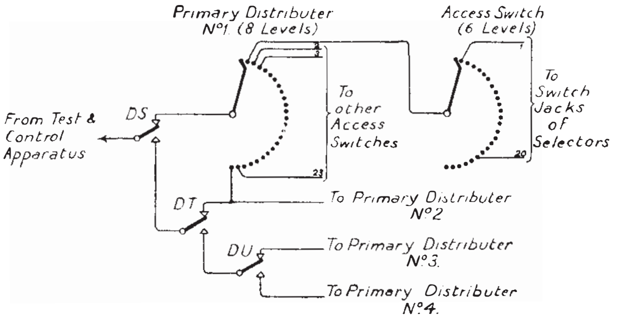

Primary Distributer (8 Levels)
Secondary Distributer (8 Levels)
Access Switch (6 Levels)
To other Secondary Distributers
From Test & Control Apparatus
To other Access Switches.
To Switch Jacks of Selectors 1 - 20
23
20

FIG. 2*a*.


Primary Distributer N°1. (8 Levels)
Access Switch (6 Levels)
From Test & Control Apparatus
DS
To other Access Switches
To Switch Jacks of Selectors
2
3
23
1
20
DT
To Primary Distributer N°2
DU
To Primary Distributer N°3.
To Primary Distributer N°4.

Contacts DS, DT, & DU, are contacts of the switching relays used to switch the testing connections through when making a continuous routine test

FIG. 2*b*.

(10) Stop the routiner when a fault is encountered and give an alarm. In most cases an alarm is given after the expiration of a certain period from the commencement of each test, if the test has not been satisfactorily completed within that period. In a few cases an alarm is given if the whole test cycle is not completed within a certain time. The routiner stops due to the fact that the application of the following test depends upon the satisfactory completion of the test in progress.

(11) Provide by means of a key restoration to normal of the testing equipment and a re-test of the same set of apparatus when a fault occurs. A key, " Reset," is provided by which a " Reset Relay " is operated, the contacts of which are connected in such a manner that they disconnect the holding circuits for alarm relays, provide a release or homing circuit for each testing switch and operate a relay to delay the restart of the test cycle. The operating circuits of relays associated with the test switch are disconnected during the homing of that switch.

(12) Provide remote control of the " Reset " facility. Jacks, spaced at convenient distances, are provided on the racks of the apparatus to be tested and connected to the " Reset Relay." With each routiner a plug, cord and pear push are provided and by inserting the plug into any one of the jacks mentioned above the " Reset Relay " in the routiner may be operated by the maintenance officer while observing any set of apparatus on which a fault exists.

(13) Provide, by means of a key, stepping to the next set of apparatus and restoration to normal of the testing equipment when a fault occurs. A key, " Step On," is connected in such a manner that it performs similar functions to those provided by the " Reset Relay " and in addition operates the relay which would normally operate at the finish of the test cycle in order to step the access equipment.

(14) Provide fault imitation keys to check that the routiner will give an alarm when particular faults are encountered. Keys are connnected in such a manner

as to simulate faults which would seriously interfere with the general service either in the normal way or when the routiner is in use.

(15) Provide an indication that tests on all associated equipment have been completed. A " Routine Finished " relay is connected to the contact of the primary distributor following the last equipped contact. The operation of this relay gives lamp and alarm indication.

A general outline of the operating procedure may be of interest at this stage.

Before commencing a routine test, it is essential that certain tests shall be applied to ascertain that the routiner will function correctly when certain faults are encountered. In order to do this a " Fault Imitation " key is thrown and then the start key. The routiner will commence operating and when the particular test is made the simulated fault should cause the routiner to stop and give an alarm. The reset key may then be thrown, one fault imitation key restored and another operated, when on release of the reset key the routiner will recommence. This procedure is followed until all the fault imitation keys have been operated in turn.

To start the routiner for a normal test of the whole of the associated sets of apparatus the " Start Key " is thrown. The routiner will then proceed with the testing until it encounters a fault, when an alarm will be given by means of a local trembler bell and the main alarm system which includes the rack pilot lamp.

Particulars of the fault as indicated by the test lamp, and the switch or set of apparatus being tested are recorded. The latter is indicated by the lamps associated with the access equipment.

The maintenance officer may now investigate the fault if he considers that additional information would be helpful or that it may be readily cleared. If the fault is cleared the " Reset Key " should be momentarily operated for sufficient time to allow the test switch to return to normal. The same set of apparatus will then be re-tested. If the fault has not been cleared the " Step On Key " should be momentarily operated, after which tests will commence on the next set of apparatus.

On completion of the normal routine test an alarm is given. The maintenance officer may now use the routiner for the purpose of continuously routine testing those sets of apparatus in which faults have been discovered and not cleared during the normal routine test. In this connection the " Continuous Routine Key " is thrown and then the " Primary Distributor Stepping Key " manipulated until the primary distributor reaches the access switch with which the particular set of apparatus is associated. The " Access Switch Stepping Key " should now be operated to step the access switch to the required set of apparatus. The associated lamps indicate the positions of the distributor and access switch as they are moved. Should the routiner have two primary distributors and the required apparatus be associated with the second, the " Distributor Selecting Key " should be thrown prior to the manipulation of the stepping keys, thus giving direct stepping to No. 2 distributor. The " Start Key " should now be operated and the set of apparatus will be continuously routined.

The apparatus being tested may be observed throughout the tests and, when a fault occurs, the routiner may be " Reset " by means of the pear push and cord previously mentioned, without the necessity for the observing officer's return to the routiner.

It may so happen that the fault is only connected with one test of the routiner; in this case certain other tests may be cancelled by throwing the relevant " Test Cancel Keys " where fitted. These may also be thrown when making a general routine test to reduce the testing time, or when it is desired to locate faults of a definite nature.

While the officer is in attendance the main alarm system is disconnected from the local routiner alarm (trembler bell) by the operation of the " Main Alarm Key."

There are other uses for the " Continuous Routine Key." For instance, if during a general routine a fault is located which has previously given trouble (a fault of an intermittent nature) the continuous routine key may be operated previous to the reset key and the fault investigated as in the case of a continuous routine test. Afterwards the continuous routine key may be restored and the general routine resumed. Another use is to enable the routiner to test a particular group of switches. In this case the routiner is stepped to a particular switch as for a continuous routine test and after the test cycle has commenced the continuous routine key is restored.

FIRST CODE SELECTOR ROUTINER.

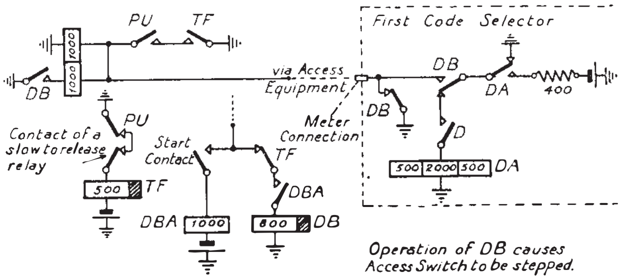
In this routiner a " Control Switch " and a " Test Switch " are fitted. The Test Switch changes the tests to be applied in the required sequence while the Control Switch changes the conditions to the access leads as the tests progress.

Where two primary distributors are fitted, a " Distributor Selecting Key " is provided to switch the primary distributor stepping circuit direct to No. 2 distributor when manually stepping prior to a continuous routine test. If three primary distributors are fitted, two keys would be provided.

Where more than three primary distributors would be required, one primary distributor and four or more secondary distributors are fitted as required. This arrangement, as shown in Fig. **2**_a_, avoids the use of a large number of switching relay contacts, as shown in Fig. **2**_b_, which are potential points of failure.

In view of the difficulty of automatically busying outlets on selector levels, the vertical and rotary stepping tests are usually made by manual routine testers, which are associated with the necessary points by means of the test jack provided on each selector. In some of the earlier exchanges, however, all the points required for this purpose were not provided and it was therefore necessary to seek some alternative means of access. Since the auto routiner access points are similar to those required for the manual tester, a test jack is fitted common to the access equipment and can thereby be associated with each selector in turn, or with any particular selector as required. The points of access on each selector are P, +, − ingoing connections, the meter connection and the K relay.

Before the cycle of tests is commenced, it is necessary to ascertain whether or not the selector position is equipped. Various methods are employed to effect this. In some exchanges the meter connection of equipped selectors is continuously earthed except for the metering period during which battery is applied. This fact is utilised to determine that the position is equipped. A differentially wound relay, with the coils normally in opposition is so connected to the selector meter lead (see Fig. **3**_a_) that if either earth or battery is found the relay will operate and cause the routiner to proceed with the tests. If the differential relay does not operate, the release of a slow relay steps the access switch to the next position. The " Unequipped " test is followed by the " Selector Busy " test, for which conditions are applied to the private to determine whether or not this is earthed. Should the private remain earthed for



Operation of DB causes Access Switch to be stepped.

FIG. **3**_a_.

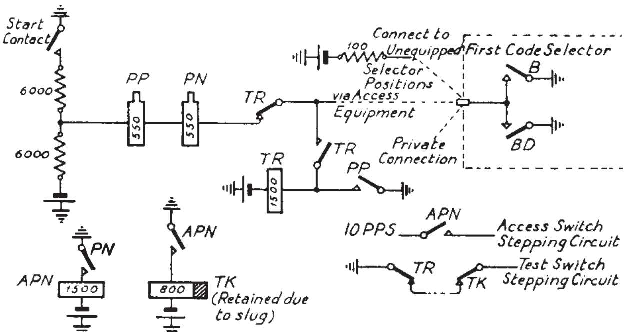


FIG. **3**_b_.

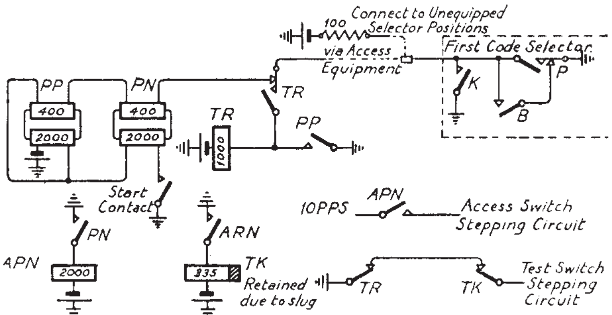


FIG. **3**_c_.

more than 2—4 mins. an alarm is given. In many other exchanges the " Position Unequipped " and " Selector Busy " tests are applied simultaneously during the releasing period of a slow relay, as shown in Figs. **3***b* and **3***c*, where polarised relays are used. In these cases the two polarised relays are connected on the one side to the centre point of a battery and earth-connected resistance and on the other to the private. These relays have been arranged to discriminate between earth (busy), battery (unequipped) or disconnected (free) conditions. If battery be found, the operation of relay PN causes the access switch to step to the next position, while if PP operates, further tests are delayed until the selector becomes free or if still busy after 4½ mins. an alarm is given.

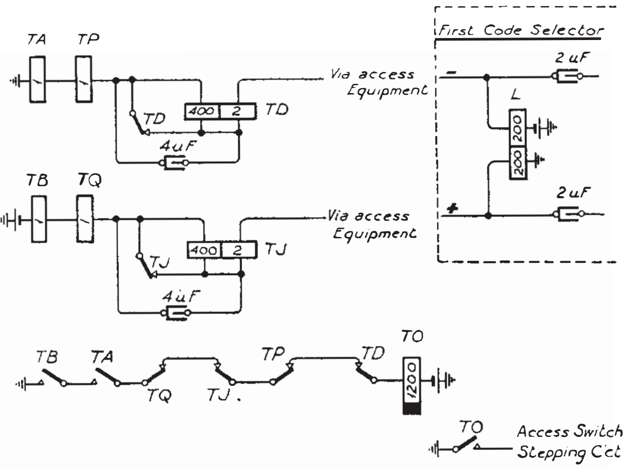


FIG. **4***a*.

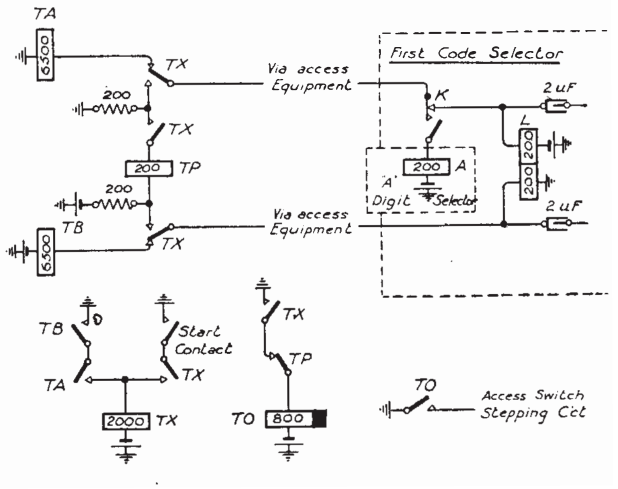


FIG. **4***b*.

It will be noticed that all negative conditions are tested during delay periods.

Having determined that the selector position is equipped and the selector disengaged the private of the selector is earthed by the routiner while the ingoing lines are tested. The latter is accomplished by connecting three relays (in some cases two) to each line, as shown in Fig. **4***a*. TD or TJ operate should direct battery or earth, respectively, be found; TP or TQ if the potential is abnormal due to contacts on the banks of the preceding switches; and TA and TB only if correct potentials, with the usual margins, are obtained. Where split loop impulsing, involving switching operations on the ingoing leads when the selector L relay is operated, is employed, the test is as follows:—A high resistance relay is connected to each line to test for continuity without operating the "L" relay, after which a Wheatstone network is applied, see Fig. **4***b*, to test for any out-of-balance conditions.

The " L " relay of the selector having been operated, the private should be earthed. This is verified by a simple test at this stage.

In the case of " Forced Release " of the selector, earth is removed from the holding circuit of the K relay and hence in order that the routiner may determine that " Forced Release " has occurred this is made an access point. It is also used to determine when a free " A " Digit Selector has been found. The latter test has made it necessary in some exchanges to use the connection between the K relay and the rotary switch drive magnet for the access point. This is due to the K relay being held from the First Code Selector instead of the " A " Digit Selector. The respective access points and associated routiner connections are shown in Figs. **5***a* and **5***b*. It will be seen from Fig. **5***a* that if after a given delay period (this allows ample time for the hunting of the " A " Digit Finder and the resultant switching operations) relay TE is not operated then earth is not being returned from the " A " Digit Selector. In Fig. **5***b* relays TE and TES will operate while the " A " Digit Finder is hunting and, when hunting ceases, relay TES will release due to the absence of direct earth and thus operate TER. If the " A " Digit Selector has not been seized, this will be proved in the next test by relay TE

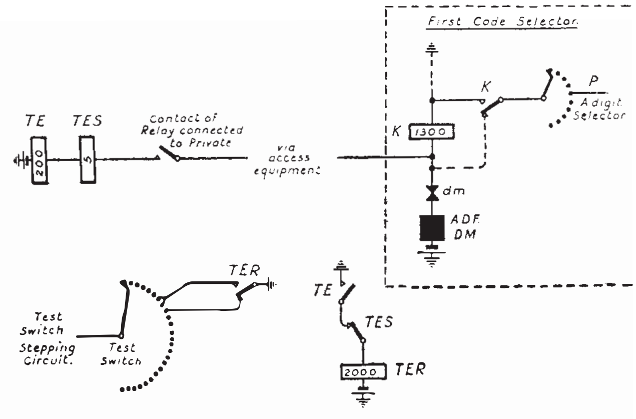


FIG. 5*a*.

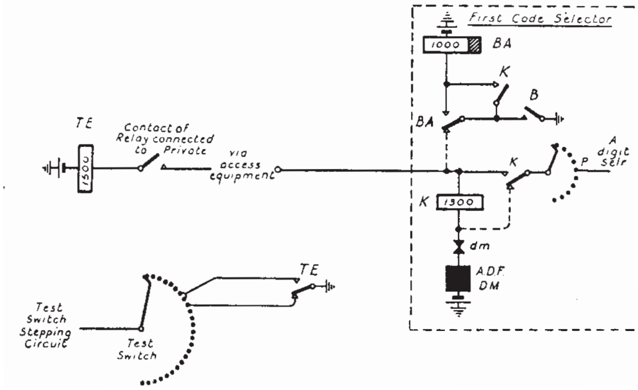


FIG. 5*b*.

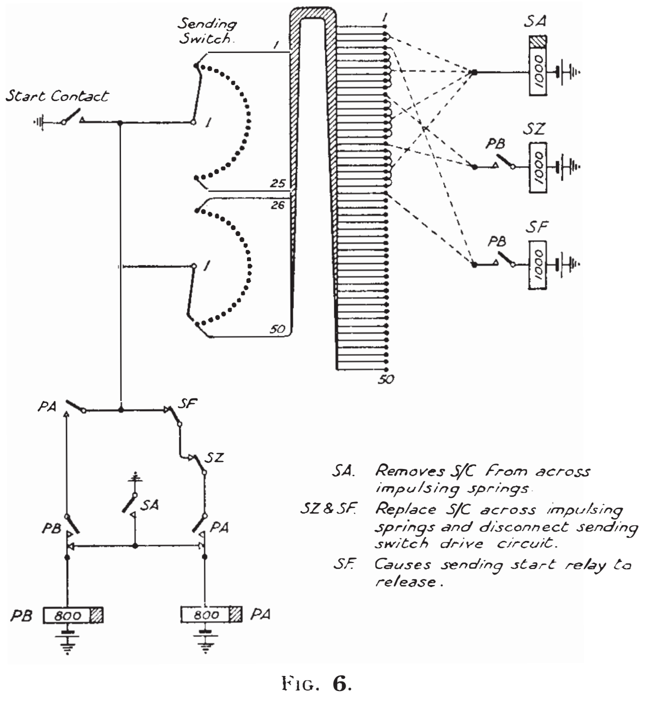
remaining operated when it should have been released due to " Forced Release " condition.

After the " Forced Release " test has been applied the ingoing loop is opened for a given period to allow the selector to restore to normal. The private is guarded by the routiner during this period. The selector is then re-seized and a single digit sent to the " A " Digit Selector. The " Forced Release " from the Director is then tested in a similar manner. Owing to the length of time required to ascertain that " Forced Release " conditions are received from the " A " Digit Selector and Director respectively, cancel keys are fitted in order that either or both of these tests may be cancelled if so required.

A 50-point sending switch is used in this routiner. The connections of one level of the switch are wired to a tagblock as shown in Fig. **6** and the sending control relays are commoned on this tagblock as required for the sending of the predetermined four digits, a single digit to test the Director " Forced Release " and a train of three digits to set up " Through " conditions. Keys are not used for setting up the digits as only specially allotted digits may be sent. The " Through " conditions are established *via* a spare selector level, usually " Second Code," back to the routiner and so are under the control of the routiner.

The " Manual Holding " feature of the selector is tested by connecting battery to the outgoing positive lead while two slow relays release in tandem, the ingoing leads being disconnected at the same time. When both relays have released, the private is tested to ascertain if it be still guarded by the selector. In some equipments the period of relay release is augmented by a 1.5 sec. stepping pulse to the test switch. This period is designed to allow full release of the selector, before the private is tested, should the " Holding " feature be faulty.

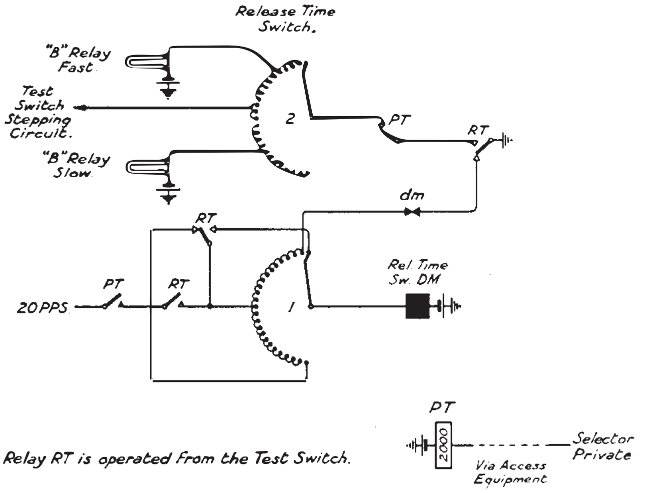
The application of the next test is delayed while the selector is allowed ample time to restore to the normal " Through " conditions. The battery and earth connections of the outgoing leads are reversed and the meter connection tested for the metering condition. Resistances equal to the test or adjust figures may be introduced into the outgoing leads by key operation previous to commencing the routine. This feature is used in conjunction with continuous



SA. Removes S/C from across impulsing springs.
SZ & SF. Replace S/C across impulsing springs and disconnect sending switch drive circuit.
SF. Causes sending start relay to release.

FIG. **6**.

routine testing to ensure that the selector D relay is in correct adjustment and remains so during several consecutive tests. Experience has shown that this feature is not warranted and hence it will not be included in future routiners.



Relay RT is operated from the Test Switch.

FIG. 7.

Pulses are now connected to the Release Time Switch (see Fig. 7) and at the same time the selector ingoing loop is opened in order that the period during which earth is retained on the private may be timed. When the earth is removed from the private by the selector an alarm operates if the period is longer or shorter than normal.

In this routiner the fault alarm is given after $4\frac{1}{2}$ mins. A Time Check Relay (Relay No. 192A) is stepped by 1.5 sec. earth pulse. The relay commences to operate as each test is applied and is released when the test proves satisfactory. The period of $4\frac{1}{2}$ mins. is chosen as this is required for the " Selector Busy " test. The release alarm is given after 9 secs., a Time Alarm Relay (Relay No. 157A) being stepped by 1.5 sec. earth pulses. In some exchanges, Relay No. 157A is used for both alarms and is stepped by $\frac{1}{2}$ min. earth pulses for the fault condition, while in other exchanges the S and Z schemes are employed.

" Fault Imitation " keys are fitted in this routiner to simulate the following conditions:— " Direct Earth " or " Battery Contact " on either ingoing line, " Selector Position Unequipped," " Selector Busy," " Meter Fail " and " Private Disconnected."

Indication of the selector being tested is given by a shelf lamp and a shelf position lamp.

In order that traffic statistics on Directors may be more accurately analysed, a meter is arranged to record the number of times that Director meters are operated due to the functioning of this routiner.

AN ARTIFICIAL TRAFFIC MACHINE FOR AUTOMATIC TELEPHONE STUDIES.

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[*Reprinted from " Electrical Communication," October, 1928.*]

DESIGNERS of automatic telephone exchange equipments have at all times felt the need for positive data to enable them to provide the most economical, yet adequate, quantities of equipment for efficient service. Consequently close attention has been given to the theory of probability by means of which fundamental formulæ and curves have been devised, enabling the equipment engineer to determine readily the equipment quantities required to carry any known traffic with a particular switching arrangement and a specified grade of service. Various investigators engaged in probability research have produced basic formulæ, which, while being approximately in agreement for general traffic conditions, are nevertheless at variance in certain respects owing, in some cases, to the different physical assumptions made, and in other cases, to the different methods of interpreting these assumptions in developing formulæ. Each has in turn resorted to experiment to justify assumptions and to obviate laborious or impracticable mathematical work. In these experiments different methods have been employed to reproduce physically a sequence of events governed by the laws of pure chance and analogous to those obtaining in telephone traffic. So far as the writers of this article are aware, all the methods hitherto adopted required a long period of time for one experiment, and involved careful plotting on graphs of a very large number of points. As a test, the method often adopted, of obtaining from a telephone directory a random series of four-digit numbers representing the times of call originations in ten-thousandths of the busy hour, was tried and it was found that with two men employed on the work there was an average interval of 20 seconds between the recording of two successive call originations on a graph. In this method each originating call is assumed to continue for a constant holding time—usually 2 minutes—and the number of simultaneous calls in progress at any interval is indicated as shown in Fig. **1**. If ten switches are being considered, any call arriving whilst ten simultaneous calls are in progress is lost. This condition is reached at points " X " marked on the graph. To obtain reliable results the experiment should be continued until about 20 lost calls are recorded so that to verify conditions with a grade of service of 1 in 1,000 (P = 0.001) it would be necessary to record 20,000 calls on the graph. This, at the rate indicated, would occupy 222 man-hours and even if by practice this time could be reduced it will be seen that one experiment involves a considerable amount of labour and time.

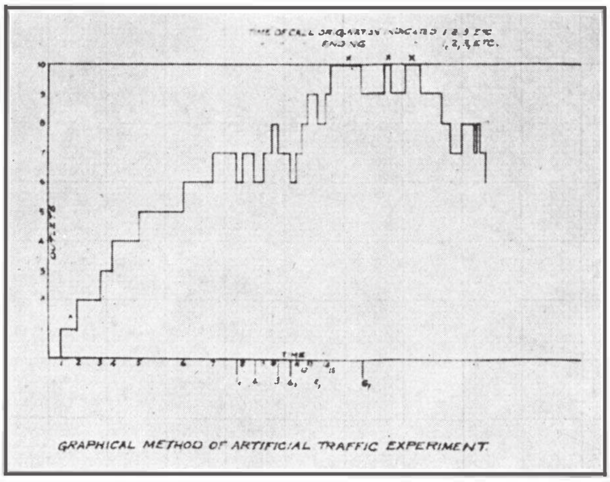


FIG. 1.—SIMULTANEOUS CALLS IN PROGRESS AT ANY INTERVAL.

The object of this article is to outline a development which has been undertaken with a view to producing a machine for the production, distribution and analysis of artificial traffic so that experiments may be carried out within a reasonably short period of time and with a considerable reduction of the tiresome work involved in graphical methods. Whilst the design of the machine described here is limited to the study of the comparatively simple trunking arrangement known as two-group grading, the principle involved readily admits of an extension of its application to more general cases.

Two main requirements have to be met in the machine :

1. It must produce a random time distribution of originated calls.
2. It must give facilities for applying the traffic so produced to particular switching arrangements, in such a manner that the traffic distribution through the system is readily obtained.

PRODUCTION OF ARTIFICIAL TRAFFIC.

The time distribution of call originations is arranged to satisfy the following conditions :

1. Calls must originate in a purely chance manner.
2. The calling rate taken over a long period must be uniform.
3. A large number of call originations per holding time must be possible. This means that the traffic must represent that which would originate from a large number of subscribers.

To obtain numerical results readily, steel balls such as are used in ball bearings are utilised to represent calls, thereby giving each originated call a physical identity. The random traffic distribution is obtained (Figs. **2** and **3**) by directing a stream of balls from a funnel on to a large steel ball placed above the centre of a wire grid which supports a small number of funnels connected to rubber tubes leading to the lower part of the machine. The balls, after striking the deflecting ball, are scattered in a random manner over the grid as indicated in Fig. **2** and a small proportion at chance intervals enters one or other of the funnels, which are spaced irregularly over the grid. These balls now represent originated calls, and the remainder which have fallen through the grid are directed by means of an inclined plane to a container fixed on the outside of the cabinet. The balls collected in this container are regularly transferred to the main supply at the top of the cabinet. The box containing the supply of balls is provided with an inclined glass-lined base so that an even flow of balls is supplied to the funnel. The funnel adopted, after several experiments with different shapes and types, consists of a loud-speaker horn which is hinged to the supply box so that the slope may be adjusted to the best value for an even flow. A baffle plate is fitted at the outlet from the funnel, and is operated by means of a shaft terminating in a milled nut at the side of the cabinet. This baffle plate serves to direct the stream of balls on to the deflector. The deflector is provided with both horizontal and vertical adjustments. The distribution of the balls can therefore be adjusted to cover the whole area of the grid over which they are scattered.

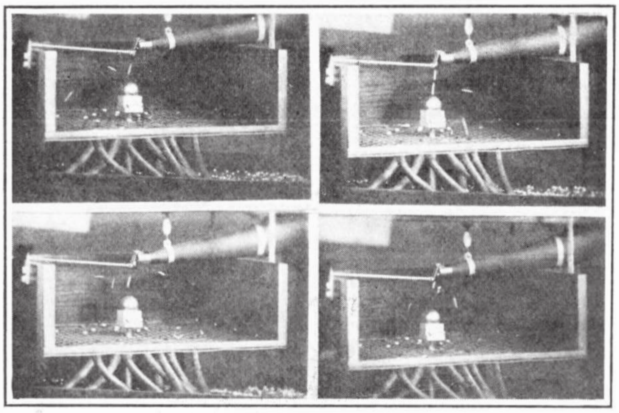


FIG. 2.—RANDOM TRAFFIC DISTRIBUTION ILLUSTRATING STREAM OF BALLS, LARGE STEEL DEFLECTING BALL, WIRE GRID AND RUBBER TUBES LEADING TO LOWER PART OF MACHINE.

METHOD OF SETTING UP SWITCH ARRANGEMENTS.

The balls which enter the rubber tubes are led through the inclined plane on which the other balls fall. They then drop into a wooden runway which directs them to the lower part of the machine representing the switching equipment. The original design represented two switching stages—a 24- or 25-point line switch stage followed by a 10-point selector stage. The arrangement is shown in Fig. **3**, and although this has been modified in the later design it is described here to indicate the facilities which may be provided.

In Fig. **3** the multipled 25 outlets from a group of line switches is represented by an inclined aluminium runway with 25 holes, each hole being provided with a "busying" device arranged to close it for a period equal to a call holding time whenever a ball drops into it. A ball starting from the beginning of the runway proceeds along it, passes all busy outlets and enters the first free one, thus giving a mechanical representation of a call hunting by means of a line switch for a free outlet. Before they enter the line switch runway, the balls from the wooden runway pass through a separating device which ensures a certain time interval between the arrival of two balls in the line switch runway. This is done to prevent the mechanical equivalent

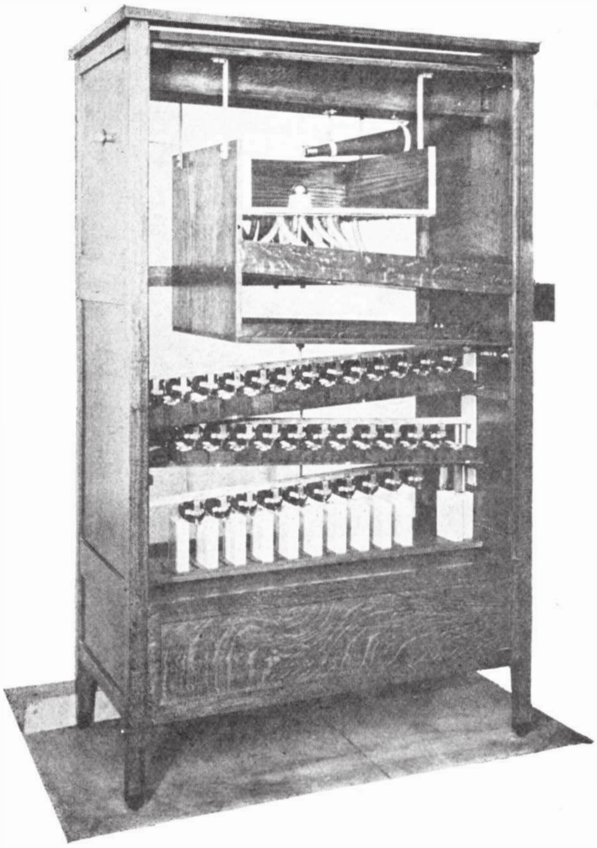


FIG. 3.—ARTIFICIAL TRAFFIC MACHINE. LOWER PART OF MECHANISM REPRESENTS SWITCHING EQUIPMENT.

of a double connection, which would otherwise occur in the machine more frequently than in actual practice. A ball which finds all line switch outlets engaged falls through a hole at the end of the runway into a tube leading to an overflow bin. This represents a call which has failed to find a free outlet on the first half-revolution of a line switch; but since a line switch continues to hunt till a free outlet is found, this ball must immediately be transferred to the beginning of the line switch runway and must be allowed to hunt again.

For convenience in designing the cabinet, the 25 outlets representing the line switch multiple are arranged in two groups, one of 13 and one of 12—the upper two runways in Fig. **3**. If it is desired to represent the 24-point multiple of the homing line switch, one of the 25 outlets is permanently " busied."

The outlet " busying " device shown in Fig. **3** consists of an ebonite roller mounted below the outlet. Attached to the side of the roller is a short glass tube the bore of which is slightly greater than 5/16″. A 5/16″ diameter steel ball is enclosed in the tube; the remaining space is completely filled with a mixture of glycerine and water, and both ends of the tube are sealed. In the free condition, the tube takes up a vertical position due to the weight of the steel ball, and in this position the roller presents a pocket to the outlet in the runway. A steel ball on reaching a free outlet, drops into the pocket, turns the roller over and drops into a runway below, parallel to the first, and leading to the next switching stage. Meanwhile the roller having been turned over is prevented from returning to the normal position by a pin which engages a pawl, the arrangement being such that the roller can rotate in one direction only. In the locked position, the roller closes the runway outlet while the glycerine tube is held in a position slightly inclined to the horizontal. In Fig. **4** the first three outlets are shown engaged. The ball enclosed in the tube rolls slowly down, the motion being restricted by the glycerine. When the ball has passed the centre of the tube its weight turns the roller over to a second normal position 180° removed from the first. In this position a second pocket is presented to the outlet which is, therefore, free again. The time taken for the roller to leave one normal position and restore to the second represents the holding time of the call. The average value of this time should be the same for all rollers to reproduce conditions corresponding to those assumed in theory.

In the original design, a ball having taken a line switch outlet is carried by means of the runway below the rollers to the top of a similar runway equipped with 10 outlets representing the multipled outlets from one level of a group of selectors. The delay between the seizure of a free line switch outlet and the subsequent seizure of a selector outlet is somewhat longer in the traffic machine than in actual automatic switching. The runways are, however, arranged so that the time between the commencement of hunting at the line switch stage and the commencement of hunting at the selector stage is the same for all calls. Thus the slower hunting speed and delay between stages does not affect the traffic distribution.

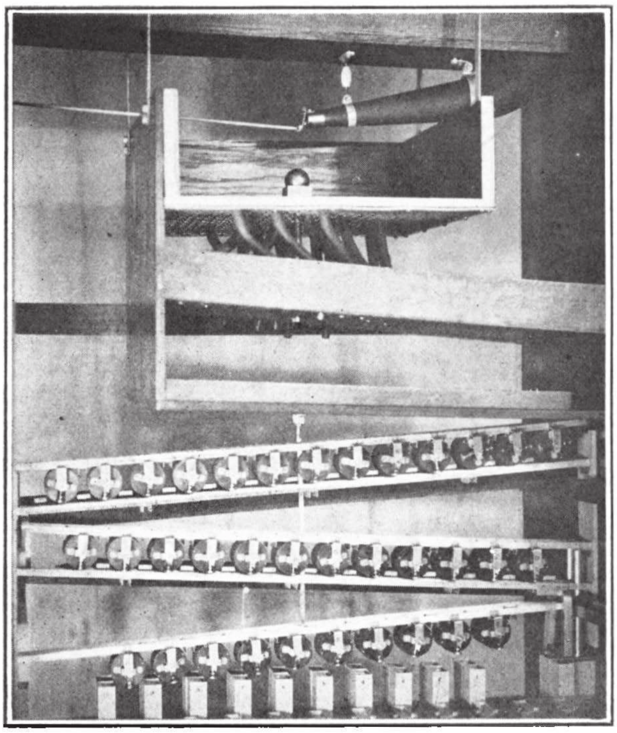


Fig. **4**.—Artificial Traffic Machine. First three outlets shown engaged by means of " busying " device.

Since the traffic from subscribers' line switches is not all routed over the same level of first selectors, the artificial traffic machine must be arranged to satisfy this condition. For the purpose of traffic experiments it is not necessary to study more than one level; traffic to the other levels need not be analysed. A mixture of two sizes of balls is, therefore, used and, after leaving the line switch runway, the balls pass a separating device which routes the larger size to the selector runway and the smaller size, representing traffic to other levels, to an analysis bin. The mixture of the two sizes thus controls the average value of the fraction of the total traffic routed over the level which is being studied.

The outlets in the selector runway are tested in turn in exactly the same manner as already indicated, and when a free outlet is found, the ball, having turned the roller over, is dropped into an analysis bin placed below the roller. If all 10 outlets are busy the ball drops through a hole at the end of the runway into a separate bin. Thus the number of calls received by any one outlet or the number of lost calls is given by the number of balls found in the corresponding bin at the end of the test.

In order to carry out tests on the distribution of traffic at the line switch stage, two sets of analysis bins, corresponding to the two halves of the line switch runway, are provided. These analysis bins can be seen in Fig. **3**, numbered 1, 5, 10, 15, 20 and 25. When these bins are placed in position alongside the runways, the balls which take line switch outlets drop into short channels each leading to a bin corresponding to a particular outlet.

Facilities for two-group grading are provided by duplicating the whole of the mechanism representing the switching arrangements as described above. The rubber tubes from the wire grid are divided into two groups leading to two wooden runways which serve the two sets of line switch and selector runways. Each of the duplicate line switch and selector runways consists of two channels fitted close together and equipped with one set of rollers double the width of the first rollers so that the two outlets controlled by one roller may be " busied " by a ball from either channel. The double runway is mounted alongside the first, and the partition between the single runway and the adjacent channel of the double runway is provided with a series of gates, one between each pair of outlets. The arrangement is shown in Fig. **5**. At the beginning of the line switch or selector runways, the balls enter the two outer of the three channels so that if it is desired to run the two groups of outlets with no grading, the centre channel is not used. If some of the outlets in the two groups are to be graded, the gate before the first graded outlet is thrown across the single runway, so that a ball finding the individual outlets in that runway engaged, is deflected into the centre channel and proceeds to test the outlets which are also being tested by balls in the outer channel of the double runway. A trunking arrangement with individual outlets following graded outlets (called " reversed grading " by the British Post Office) can be provided by setting the gate after the last graded outlet across the centre channel, so that a ball which finds the graded outlets in the centre channel engaged, is returned to the single runway to test the last group of individual outlets.

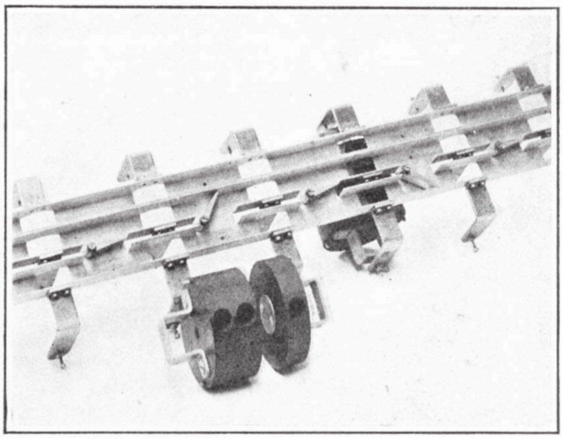


FIG. **5**.—DOUBLE RUNWAY PROVIDED FOR TWO-GROUP GRADING.

Arrangements are also provided in the machine for enabling a call to be routed from either of the two line switch multiples to either of the two selector groups. Thus, a ball having taken a particular line switch outlet, may either drop into the channel immediately below it and leading to one selector runway, or, by means of a deflector which clips on to the channel below the roller, the ball on falling out of the roller may be deflected to the runway which leads to the other selector group.

The trunking scheme of the machine as described above is shown in Fig. **6**.

It was proved that with the design of " busying " device described above, owing to the difficulty of adjusting all rollers to have the same average holding time, it was not possible to obtain any accurate results from tests. This difficulty was caused by the slight differences in the several timing devices and the individual adjustments which were necessary for each. It was, therefore, decided to introduce a timing device with a common control, the arrangement being such as to utilise the first model as far as possible.

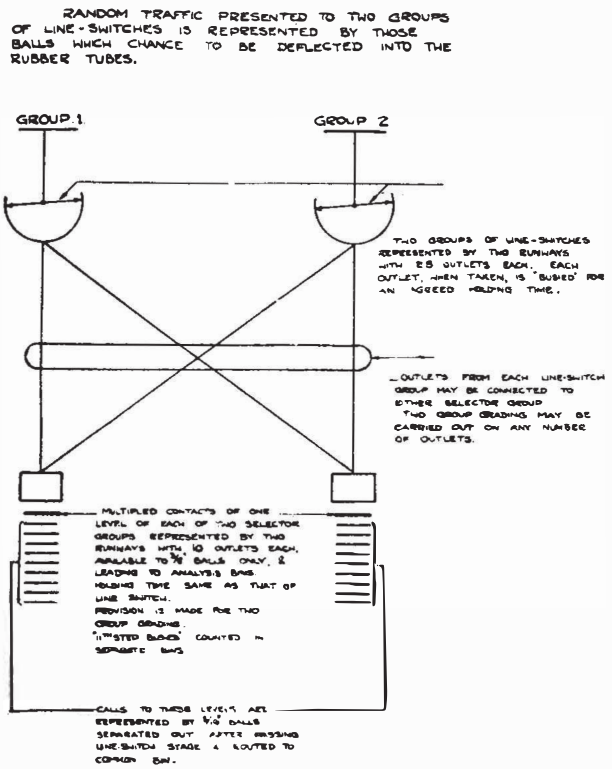

RANDOM TRAFFIC PRESENTED TO TWO GROUPS OF LINE-SWITCHES IS REPRESENTED BY THOSE BALLS WHICH CHANCE TO BE DEFLECTED INTO THE RUBBER TUBES.
GROUP 1
GROUP 2
TWO GROUPS OF LINE-SWITCHES REPRESENTED BY TWO RUNWAYS WITH 25 OUTLETS EACH. EACH OUTLET, WHEN TAKEN, IS 'BUSIED' FOR AN AGREED HOLDING TIME.
OUTLETS FROM EACH LINE-SWITCH GROUP MAY BE CONNECTED TO EITHER SELECTOR GROUP
TWO GROUP GRADING MAY BE CARRIED OUT ON ANY NUMBER OF OUTLETS.
MULTIPLED CONTACTS OF ONE LEVEL OF EACH OF TWO SELECTOR GROUPS REPRESENTED BY TWO RUNWAYS WITH 10 OUTLETS EACH, AVAILABLE TO 3/8" BALLS ONLY, & LEADING TO ANALYSIS BINS.
HOLDING TIME SAME AS THAT OF LINE SWITCH.
PROVISION IS MADE FOR TWO GROUP GRADING.
"11TH STEP BLOCKS" COUNTED IN SEPARATE BINS
CALLS TO THESE LEVELS ARE REPRESENTED BY 1/2" BALLS SEPARATED OUT AFTER PASSING LINE-SWITCH STAGE & ROUTED TO COMMON BIN.

Fig. 6.—Trunking Scheme of Artificial Traffic Machine.

The timing arrangement adopted is shown in Fig. 7, and consists of a series of shafts, one running below each set of rollers, and all shafts being driven through gearing from a small electric motor fitted inside the cabinet. Each shaft carries a number of wheels (one per roller) which are driven through a friction clutch. The glycerine tubes are removed from the rollers, and one of the two pockets is filled in to load the roller, so that normally it takes up a position with the other pocket open to the runway. In this free position, the corresponding wheel on the rotating shaft is prevented from turning by means of a pawl which engages with a notch in the wheel. When the outlet is taken, the roller turns over as before, and in doing so, a pin, fitted in the side, strikes the pawl, and raises it out of the notch in the wheel, which immediately moves away from the normal position. The ball having dropped out of the roller, the latter tends to return to normal, but is prevented by the pawl, which now rests on the rim of the wheel against which it is forced, both by its own weight and by the roller. The outlet is thus held "busy" until the notch in the wheel has made a complete revolution, when the pawl drops in and releases the roller, and at the same time locks the wheel again.

One complete turn of the shaft, therefore, represents a call holding time, and since all shafts are controlled by the same motor, the holding

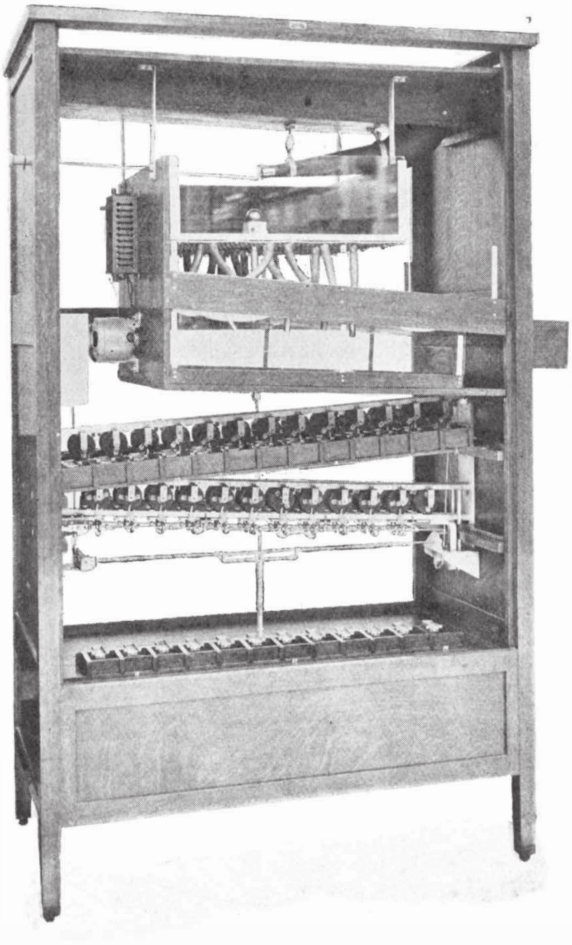


Fig. 7.—Artificial Traffic Machine with Common Control "Busying," Device.

time of all outlets is the same. By varying the speed of the motor, the holding time may be adjusted within limits to any desired value.

The introduction of this type of " busying " device in the original model permits the use of only 23 of the 25 outlets in each line switch group (in Fig. **7**: outlets 12, 13 and 25 are shown permanently " busied "). The capacity of the machines, therefore, reduced for the present to one switching stage with facilities for studying the traffic distribution in two groups of outlets, each group consisting of any number of outlets up to 22. The arrangement for direct or reversed grading between these groups remain unchanged.

Although the reduction to one switching stage reduces the scope of the machine, it is possible with the single stage to study problems associated with the standard 10-group selector or with the 20-group selector. In this way the accuracy of the underlying principle of the machine may be tested and the machine may then be applied to the solution of problems such as arise, for example, with reversed grading. If required, arrangements can be made for adding the second stage.

METHOD OF MAKING TESTS.

Before a test is run on the machine, a preliminary experiment must be made to ascertain that a satisfactory volume of traffic is being obtained. The balls are allowed to run from the funnel, and the baffle plate and deflecting ball are adjusted to give a satisfactory distribution over the grid. The wooden runways leading to the lower part of the machine are closed to prevent the balls from proceeding further, and the time taken for a number of calls to originate is measured. From this the number of calls per holding time —*i.e.*, the traffic—is obtained, and if any change is required to the value given, this can be effected either by adjusting the number of rubber tubes or by altering the position of some of them on the grid.

To commence a test on both line switch and selector stages, the required grading and cross-connecting arrangements are made, and the balls are allowed to run through the machine until a number of calls are in progress. During the preliminary run all the balls are collected in a common bin placed below the selector runways. These calls do not count in the test. The test interval commences from the time when all the analysis bins, mounted on a platform at the bottom of the machine, are pushed forward into position below the rollers.

At the end of the test period, the platform with the analysis bins is withdrawn and the common bin is replaced. The aperture between the baffle plate and the funnel mouth is then closed to stop the flow of balls.

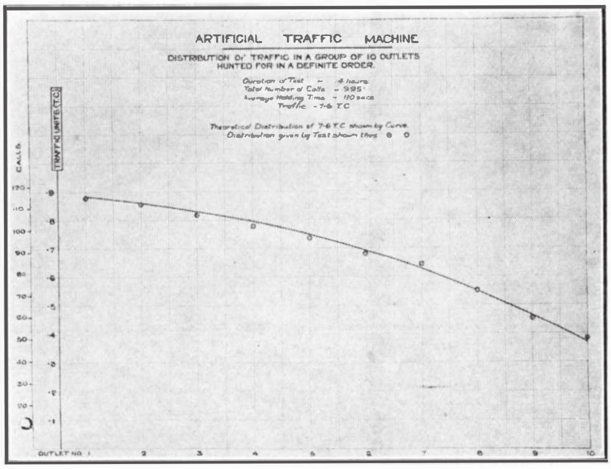


FIG. **8**.

A test on the line switch stage only, is carried out in the same manner except that during the preliminary run the balls are allowed to proceed to the selector stage, or in the present model, to a common starting bin. The test period commences when the group of wooden analysis bins is placed up against the runway and ends when these bins are withdrawn.

RESULTS OF TESTS.

The machine in its modified form has been employed to determine the distribution of traffic in certain simple cases where the solution can also be derived mathematically. Results of such experiments are reproduced in graphical form in Figs. **8** and **9** and in tabular form in Tables I. and II. It will be seen that in Fig. **8** the mechanical analysis closely approximates to that deduced by theory; the machine, therefore, furnishes a direct means of solution for the complex cases where precise mathematical solutions are too laborous or are impossible.

TABLE I.

Test of Distribution of Traffic in Group of Ten Outlets Hunted for in a Definite Order.

Summary of Results.

Duration of Test	4 hours.
Total Number of Originated Calls	995.
Average Holding Time of Calls	110 seconds.
Traffic (a)	7.6 T.C.

Distribution.

Outlet No. (r)	Calls	Traffic Units (T.C.)		Calls	
		Test	Theoretical (a_r)	Test	Theoretical
1	115	.879	.884	115	115.6
2	112	.856	.860	112	112.5
3	107	.817	.828	107	108.3
4	102	.779	.796	102	104.3
5	96	.734	.748	96	98.0
6	89	.680	.692	89	90.6
7	84	.641	.625	84	81.8
8	72	.550	.548	72	71.8
9	59	.451	.461	59	48.3
10	50	.382	.369	50	60.4
O/F	109	.833	.789	109	103.1
Totals...	995	7.602	7.600	995	994.7

TABLE II.

Test of Distribution of Traffic in a Two-Group Grading with Two Individual and Nine Common Outlets.

Summary of Results.

Duration of Test	5 hours.
Number of Calls to Group 1	475
" " " " " 2	971
Total Number of Calls	1,446
Average Holding Time of Calls	104.6 seconds.
Traffic to Group 2	2.82 T.C.
Traffic to Group 1	5.78 T.C.
Total Traffic	8.6 T.C.

Distribution.

Outlet No.	Calls	Traffic Units (T.C.)		Calls	
		Test	Theoretical	Test	Theoretical
1 Grp. 1	124	.737	.739	124	124.1
1 ,, 2	146	.868	.852	146	143.1
2	145	.862	.869	145	146.0
3	142	.844	.838	142	140.9
4	137	.815	.803	137	135.0
5	128	.761	.761	128	128.0
6	124	.737	.708	124	119.0
7	113	.672	.643	113	108.0
8	99	.589	.570	99	95.8
9	83	.493	.490	83	82.4
10	67	.398	.400	67	67.3
O/F	138	.821	.927	138	155.9
Totals...	1,446	8.597	8.600	1,446	1,445.5

The points through which the theoretical curve in Fig. **8** is drawn are those given in column 4 of Table I. and are derived from the formula:

$$a_r = \frac{\dfrac{a^{r-1}}{r-1\,!}}{1 + a + \dfrac{a^2}{2\,!} + \ldots + \dfrac{a^{r-1}}{r-1\,!}} - \frac{\dfrac{a^r}{r\,!}}{1 + a + \dfrac{a^2}{2\,!} + \ldots + \dfrac{a^r}{r\,!}}$$

where a_r = traffic carried by the rth choice switch of a fully available group hunted for in a definite order, and

a = total traffic approaching the group. The expression:

$$\frac{\dfrac{a^r}{r\,!}}{1 + a + \dfrac{a^2}{2\,!} + \ldots + \dfrac{a^r}{r\,!}}$$

represents the probability that a group of r switches is completely occupied and can be denoted by p_r. The formula for a_r can, therefore, be expressed as:

$$a_r = a(p_{r-1} - p_r).$$

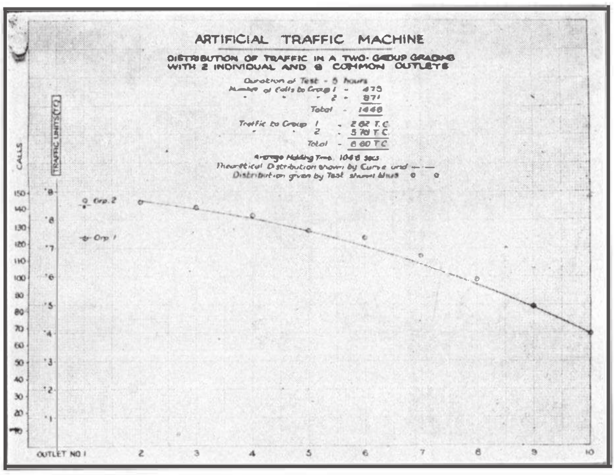


FIG. **9**.

The theoretical curve in Fig. **9** is deduced in a similar manner. The traffic carried by each individual first choice is calculated from the formula, and the total overflow to the common second choice is then known. The total traffic which, presented to the first choice of a single group of ten outlets, would give the same overflow to the second outlet can then be determined.

This traffic is then substituted for the term " *a* " in the above formula to give the approximate theoretical traffic distribution over the common outlets. Fig. **9** indicates the extent to which the experiment agrees with the approximate mathematical method.

FURTHER DEVELOPMENTS.

The development of this model has led to the proposed design of an electrically controlled system in which the present arrangements for giving a random time distribution of originated calls would be retained while the switching arrangements would be represented by groups of relays and message registers, the latter giving the traffic analysis by direct readings. Such a scheme would be more flexible than the mechanical arrangement; and with the provision of a small distributing terminal assembly, would give facilities for studying any trunking arrangement.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31ST DEC., 1928.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
613,408	517	3,975	51,625	122	London	24,728	72,930	2,404,162	112,209
79,224	2,184	20,639	65,796	2,634	S. East	4,058	53,144	211,831	28,342
82,345	4,414	31,135	57,062	3,236	S. West	20,398	12,677	159,220	60,457
64,901	6,040	38,214	60,631	4,693	Eastern	24,116	40,116	122,600	68,312
98,244	8,408	45,308	59,410	3,843	N. Mid.	30,830	55,522	250,055	109,136
80,732	4,798	30,176	73,298	4,471	S. Mid.	12,147	24,175	192,946	87,515
58,743	4,730	29,871	52,928	3,311	S. Wales	6,461	26,312	124,233	71,918
105,632	8,027	26,456	50,337	4,281	N. Wales	13,687	41,089	280,174	61,604
160,362	1,481	16,409	43,641	2,511	S. Lancs.	13,849	79,155	478,925	49,265
93,962	6,225	30,838	46,888	3,018	N. East	11,715	46,380	244,011	74,617
64,859	3,893	24,521	38,080	2,134	N. West	8,661	34,851	172,339	31,548
47,863	2,523	16,127	25,687	2,702	Northern	4,909	16,335	110,801	49,163
21,666	4,566	8,404	13,782	542	Ireland N.	134	2,326	43,428	1,581
66,723	5,517	26,431	38,045	1,472	Scot. East	4,518	13,675	156,105	45,832
89,016	7,281	24,509	43,146	971	Scot. West	12,149	24,952	226,565	36,779
1,727,680	70,604	373,013	720,356	39,941	Total	192,360	543,639	5,177,395	888,278
1,693,618	70,466	371,339	713,439	40,038	Figures as at 30th Sept., 1928.	188,621	527,235	5,001,532	886,386

PROBABLE LOSS IN AUTOMATIC SWITCHING SYSTEMS WITH DOUBLE PRESELECTION.

VERY little has been published in the past on the theoretical aspect of this subject. Mention should be made, however, of articles by McHenry (*P.O.E.E.J.*, January, 1922) and Dumjohn and Martin (*P.O.E.E.J.*, July, 1922).

The following article is an abstract of a thesis by Dr. Baltzer, of Germany, dealing with the problem of loss in such a system.

Synopsis.—Brief description of Siemens system of Preselection, introducing the term "group control."

Probability that exactly 1 or 2, or 3, etc., groups of second preselectors are fully occupied.

Comparison of theoretical and practical results, as regards the effect of "group control."

Total loss in first preselector stage, excluding group control effect.

Total loss in first preselector stage, including group control effect.

Examples of the use of the formulæ for the purpose of comparison of various schemes of double preselection.

Criticism of Dr. Baltzer's Theory.

Further work by Dr. Baltzer.

- (*a*) *Double preselection schemes with direct and indirect connections to group selectors, from first preselectors.*
- (*b*) *Suggested law of the distribution of holding time.*

Most of the work published in the past, in connection with the determination of lost calls, has dealt with the loss of that traffic which arrives at a group of switches when all the available circuits from it are engaged on actual calls. This subject has been extended, however, by McHenry (*P.O.E.E.J.*, 1922), and lately by Dr. Baltzer, of Germany (extracts from whose work have appeared in "Zeitschrift Für Fermeldetechnik" of March and April, 1928), to the question of loss in double preselection systems, where additional calls fail due to the "group control" of first preselector outlets, an explanation of which is given below.

This system is, of course, the well-known one of Siemens Bros. An example of it is described in the next paragraph, the switch quantities being those made use of by Baltzer in his work. As nothing of a theoretical nature has apparently been published in the past on this particular subject, except the work of McHenry, it is thought that an abstract of the new theory of Baltzer may be of interest, especially as important problems arise in connection with the choice of the number of preselector contacts, the system of cross-connections, etc.

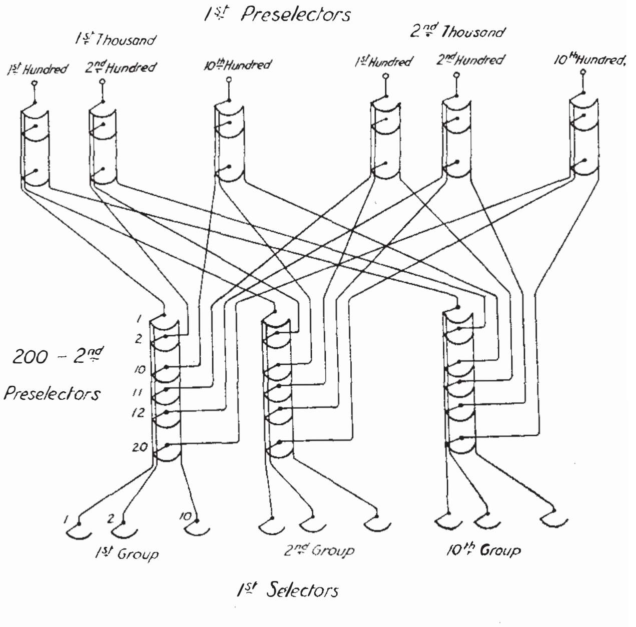


FIG. 1 Scheme of Interconnecting 1st & 2nd Preselectors.

Fig. **1** represents the system considered in the thesis. The 2000 lines are divided into 20 groups of 100 lines each. From the 100 first preselectors of one group, 10 circuits multipled to the banks of all these preselectors connect to the second preselectors, which in turn are divided into 10 groups A-K. The first circuit from the first group of first preselectors goes to a second preselector in group A, the second circuit from this group to a second preselector in group B, and so on. The banks of each group of 20 second preselectors are multipled, and connected to 10 circuits to first selectors. It may thus be seen that, if this group of 10 circuits to first selectors is in use, 10 out of the 20 second preselectors are "group controlled," *i.e.*, they cannot obtain an outlet to a first selector. Traffic testing these group controlled preselectors must thus be diverted to those groups that are not in the same condition, and, if all groups are thus controlled, the traffic is lost.

Deduction of an equation for the probability of group control among Z groups of second preselectors.

It is evidently possible that, at any instant, either no group, or only 1 group, or 2 groups, or only "Z" groups of second preselectors are fully occupied, and at most, "m" groups can be fully occupied.

Let P_0 represent the probability of complete engagement of 0 groups.

Let P_1 represent the probability of complete engagement of 1 group.

Let P_z represent the probability of complete engagement of z groups.

so that ΣP must be equal to 1.

P_z is clearly dependent on the three following variables:—

1. The number of simultaneous engagements of the second preselectors $= g$ (varying according to the laws of probability).
2. The number of groups of second preselectors $= m$ (fixed by trunking scheme).
3. The number of outlets from each group $= q$ (fixed by trunking scheme). In the above system of connections $m = q = 10$.

The probability of exactly g connections

$$= W_g = e^{-y}\frac{y^g}{g\,!} \text{ (Poisson Function) } \ldots\ldots\ldots(1)$$

where y = number of traffic units concerned.

Let Wq_1, be the probability that, with g simultaneous connections, exactly 1 group of second preselectors is fully occupied. Wq_2 the probability of full occupation of 2 groups and generally, Wq_z, the probability of full occupation of z groups

$$\text{Then } P_z = \Sigma\, W_g \,.\, W_{gz}. \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Determination of W_{g1}.

The index numbers 1, 2, 3, etc., are used to denote the single groups of second preselectors, and the following symbols are introduced:—

In the symbol W_{12}^{345}. the lower index figures represent groups fully occupied, while the upper figures represent groups not fully occupied, the groups having no part in the symbol, being in any condition.

Thus W_{12}^{345} is the probability that groups 1 and 2 are fully engaged, 3, 4, and 5 are not fully engaged, groups 6 – m being in any condition.

Evidently $W_1^{23\cdots m}$ is the probability that only group 1 is fully occupied, and since all single groups are considered similar, $W_1^{23\cdots m} = W_2^{13\cdots m} =$ etc.

Thus the total chance that only one group is

$$\text{engaged} = \binom{m}{1} W_1^{23\cdots m} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$W_1^{23\cdots m}$ must now be found.

1. There are mq outlets in all and thus if there are g connections, they may be divided amongst the outlets in $\binom{mq}{g}$ different ways.
2. If all q outlets from group 1 are engaged, then there are $(m-1)q$ free outlets among which the remaining $(g-q)$ connections may be divided, in $\binom{(m-1)q}{g-q}$ ways. But this is the number of cases favourable to the full engagement of group 1.

$$\therefore\ W_1 = \frac{\binom{(m-1)q}{g-q}}{\binom{mq}{g}}$$

In a similar way, the following general equation can be developed:—

$$W_{123\,.\,.\,.\,x} = \frac{\binom{(m-x)q}{g-xq}}{\binom{mq}{g}} \ \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

The full engagement of group 1, the remaining groups being in any desired condition (probability $= W_1$), can evidently occur in the two following ways:—

1. Group 1 is fully engaged, group 2 also fully engaged and the remaining groups in any condition. The corresponding probability $= W_{12}$ and its

magnitude is known from the foregoing.

(2) Group 1 is fully engaged, group 2 free, and remaining groups in any condition, the corresponding probability being $W_1{}^2$. Its magnitude is unknown at the moment, while W_1 is known.

$$\therefore\ W_1 = W_{12} + W_1{}^2 \text{ and } \therefore\ W_1{}^2 = W_1 - W_{12}$$

Considering the first three groups we find from similar considerations

$$W_1{}^{23} = W_1 - 2W_{12} + W_{123}.$$

Correspondingly we find the general equation

$$W_1{}^{23\,\cdots\,m} = \binom{m-1}{0} W_1 - \binom{m-1}{1} W_{12} \pm \text{---}$$

$$\pm \binom{m-1}{m-1} W_{12\,\text{--}\,\text{--}\,m}$$

$$= \sum_{x=1}^{x=m} (-1)^{x-1} \binom{m-1}{x-1} W_{12\cdots x} \quad \ldots\ldots(5)$$

Combining equations 3, 4, and 5, we obtain

$$W_{q_1} = \frac{\binom{m}{1}}{\binom{mq}{g}} \sum_{x=0}^{x=m-1} (-1)^x \binom{m-1}{x} \binom{mq-(x+1)q}{g-(x+1)q} \quad \ldots\ldots\ldots\ldots\ldots(6)$$

In the same way, it can be shown that

$$W_{q_z} = \frac{\binom{m}{z}}{\binom{mq}{g}} \sum_{x=0}^{x=m-z} (-1)^x \binom{m-z}{x} \binom{mq-(x+z)q}{g-(x+z)q} \quad \ldots\ldots\ldots\ldots(7)$$

Now, substituting $(m - n)$ for z, it can be understood that exactly $(m - n)$ groups may be engaged, only if there are more than $(m - n)q$, and less than $(mq - n)$ connections at once. A test of equation (7) gives this result.

Equation for P_z or P_{m-n}.

In equation (2), if z is made equal to $(m - n)$, as a basis for simplification of calculations, the combination of (2) and (7) results in

$$P_{m-n} = \sum_{g=(m-n)q}^{g=mq-n} \left[\frac{e^{-y} y^g \binom{m}{m-n}}{g!\ \binom{mq}{g}} \sum_{x=0}^{x=n} (-1)^x \binom{n}{x} \binom{nq-xq}{g-(x+m-n)q} \right] \quad \ldots\ldots\ldots\ldots(8)$$

This can be given the following form :—

$$P_{m-n} = \binom{m}{n} \frac{e^{-y} y^{mq-n}}{mq!} \sum_{x=0}^{x=n-1} (-1)^x \binom{n}{x} \frac{(nq-xq)!}{[(n-x)q-n]!} (1+S)$$

$$\text{where } S = \sum_{r=1}^{r=(n-x)q-n} \frac{[(n-x)q-n]!}{[(n-x)q-n-r]!\ y^r} \quad \ldots\ldots\ldots(9)$$

An artificial traffic test made by Messrs. Dumjohn and Martin (in *P.O.E.E.J.*, of July, 1922) with this switching system gave the results shown in column III. of Table I., with values of m, q and y, = 10, 10 and 75 respectively. Column II. gives the results obtained by Baltzer, using Equation (9). The other columns show the results obtained, using the theories of various other experts.

I	II Equation (9)	III. Dumjohn & Martin	IV. McHenry	V. Lubberger	VI. Lubberger
P_0	0.441	0.4287	0.3504	0.766	0.05
P_1	0.262	0.2554	0.3874	0.188	0.16
P_2	0.149	0.1460	0.1927	0.038	0.25
P_3	0.076	0.0827	0.0568	0.013	0.25
P_4	0.041	0.0445	0.0110	0.007	0.16
P_5	0.022	0.0201	0.0014	0.0047	0.13
P_6	0.011	0.0135	0.0001	0.0032	0.06
P_7	0.0051	0.0049	0.00008	0.0022	0.01
P_8	0.00206	0.0019	—	0.0017	0.00
P_9	0.00131	0.0012	—	0.0012	—
P_{10}	0.00092	0.0002	—	0.00092	—

Total... ... 1.014

The figures in column II. seem to compare very favourably with the results of column III., though I have, even after repeated calculations (for P_4, P_5, P_6, P_8) failed to obtain these results, the values obtained for these numbers being approx. 0.022, 0.011, 0.0061, and 0.00218. Baltzer claims that the formulæ can be easily evaluated, but the calculations are very tedious especially for large values of n, and the fact that our numerical results do not agree probably shows that a slight lack of accuracy somewhere in the working out of the formulæ is responsible for large errors.

It may be stated here that a rough idea of the average number of circuits unavailable through group control may be found by use of the mathematical expectation $= D = \sum_{z=0}^{z=m} P_z z(e-q)$

In the example quoted before, $m = 10$, $q = 10$, $e = 20$, $y = 75$ and hence D = 12 ccts. (approx.).

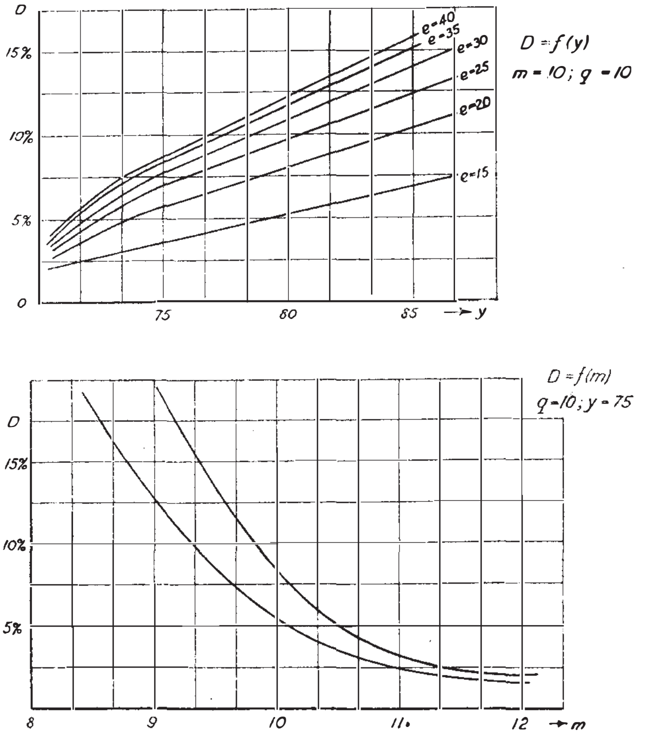


FIG. 2. D = f(y) & D = f(m)

In Fig. **2**, the upper curve shows the relation between D and traffic for various values of e, and the lower curve, the relation between D and m.

Loss in First Preselector Stage, excluding group control effect.

In order to find the probability of lost calls in this case, it is necessary to know the traffic per group of first preselectors. This can only be taken as $\lambda\, y/n$ where λ is a constant introduced to allow for the fact that all the single groups do not have their busy periods at once.

Using one of Lubberger's formulæ for this constant, Baltzer calculates that in the case of $y = 75$ T.U.s, $\lambda = 1.27$ and hence the traffic per group $= y_k = 1.27 \times 3.75 = 4.76$.

The loss in the first preselector stage excluding group control effect is then obtained from the following formula (Lubberger & Ruckle):

$$R = W_v\left(1 - e^{-(C_k - v)W_v}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots(10)$$

where $W_v = e^{-y_k} \frac{y_k^{\,v}}{v\,!}$, and C_k = number of calls per group busy hour, per group.

In our example, $y_k = 4.76$, $v = 10$, and hence $W_v = 0.014096$.

The call duration is taken as $1\frac{1}{2}$ minutes (German).

Hence R = 0.013.

Loss in First Preselector Stage, including group control.

The formula developed here, strictly speaking, holds good only for systems in which all circuits outgoing from a group of first preselectors are to be considered as similar, and where, therefore, the preselectors do not return to a home position on completion of the engagement. In systems such as that of Siemens in which the first circuits are always tested first, the equations only hold strictly when by special cross-connections the similarity of the various circuits is artificially restored, since the greatest percentage of engagements occurs on the first choice circuits.

Consider group I. of first preselectors; what holds for this group will hold for every other group on account of the symmetry of the arrangement. Symbols A, B, - - - K, are used to designate the 10 outlets from this group.

P_1 is the time during which any desired group of second preselectors is engaged. $P_A = \dfrac{P_1}{\binom{m}{1}}$ is the time during which only group A of second preselectors is completely engaged. Now, how great is the fraction of time during which circuit A_1 is engaged by group control? There are, in all, 20 circuits to group A of second preselectors. In time P_A, 10 circuits are engaged by calls and 10 by group control. If A_1 is engaged on a call, there are still 19 circuits among which the remaining 9 calls can be divided in $\binom{19}{9}$ ways. $\binom{19}{9}$ is therefore the number of favourable cases. The total number of possible cases in the time P_A. = $\binom{20}{10}$ ways of distributing the calls. The required probability is therefore $= \frac{\binom{19}{9}}{\binom{20}{10}} = \frac{1}{2}$. Thus the time during which A_1 is engaged by group control $= 1 - \frac{1}{2} = \frac{1}{2}$.

Similarly, circuits B_1, C_1, etc., have probabilities $= \frac{1}{2}$ since $P_A = P_B =$ etc., $= \frac{P_1}{\binom{m}{1}}$

Consider the time P_{AB}, $= \frac{P_2}{\binom{m}{2}}$, in which groups A and B are completely engaged. By similar reasoning, in 2/4 of the time P_{AB}, one of the 2 circuits A_1 and B_1 is engaged by group control; in $\frac{1}{4}$ of the time, both are engaged by group control; and in $\frac{1}{4}$, none is engaged by group control. Hence $P_{AB} = P_{AC} =$ etc., $= \frac{P_2}{\binom{m}{2}}$. That is to say, in 2/4 of the time P_2, some single circuit in group I is engaged by group control. Similar reasoning for P_3, P_4, P_5, etc., shows that the total time during which 1 circuit is revertively engaged.

$$= W_{r_1} = \tfrac{1}{2}\,P_1 + \frac{\binom{2}{1}}{2^2}\,P_2 + \frac{\binom{3}{1}}{3^2}\,P_3 + \dots\text{etc.}$$

$$= \sum_{z=1}^{z=m} \frac{\binom{z}{1}}{2^z}\cdot P_z. \quad \dots\dots\dots\dots\dots\dots(11)$$

The general formula becomes, for x circuits group controlled

$$W_{r_x} = \sum_{z=x}^{z=m} \frac{\binom{z}{x}}{2^z}\cdot P_z.$$

It should be emphasised here that this equation only holds for the scheme of connections of Fig. **1**.

The appropriate equations can be determined by the method shown, but will not, in all cases, give such a simple law.

Now, in the time W_{r_1}, in which any given circuit in group I. is engaged revertively, the danger of loss exists when $(v - 1) = 9$ connections exist among the unblocked circuits.

According to Poisson, that is the case during the time $e^{-y_k}\frac{y_k^{\,9}}{9!}$

Thus the danger period $= e^{-y_k}\frac{y_k^{\,9}}{9!}\,W_{r_1}$

In time, W_{r_2}, the danger period is $= W_{r_2}$ $= W_{r_2}e^{-y_k}\frac{y_k^{\,8}}{8!}$

Generally, the danger period

$$= W_{r_x} = W_{r_x}\cdot e^{-y_k}\cdot\frac{y_k^{\,v-x}}{(v-x)!} \quad \dots\dots\dots\dots(12)$$

Lost calls occur according to equation 10, when in the time W_{r_x}, still further calls originate, *i.e.*, for $y_k = C_k t$

$$R_x = W_{r_x}\left(1 - e^{-(C_k - v - x)W_{r_x}}\right) \quad \dots\dots\dots\dots\dots(13)$$

and $R = \Sigma R_x$

With $y = 75$, $m = v = 10$, $c = 20$, $y_k = 4.76$, $t = 1/40$, $C_k = 190$, we get $R = 1.62\%$.

We obtaned 1.3% neglecting group control and thus this has raised the loss by 0.3%. Such a large loss as 1.62% in the cheap preselector stage would not be economical, it being preferable to have part of this loss over the selectors

As examples of the use of the foregoing calculations for the purpose of comparison, two further schemes are compared below.

(*a*) 200 lines per group of 20 contact first preselectors, the second preselectors remaining as before. $R = 0.000515$, the loss due to group control being 0.000409.

(*b*) 10 contact first preselectors, 20 contact second preselectors, the latter being in 10 groups of 40. $R = 1.305$; loss due to group control $\rightarrow 0$.

To give some idea of the effect of group control as the traffic varies, the graph is shown of loss plotted against traffic, in Fig. **3**.

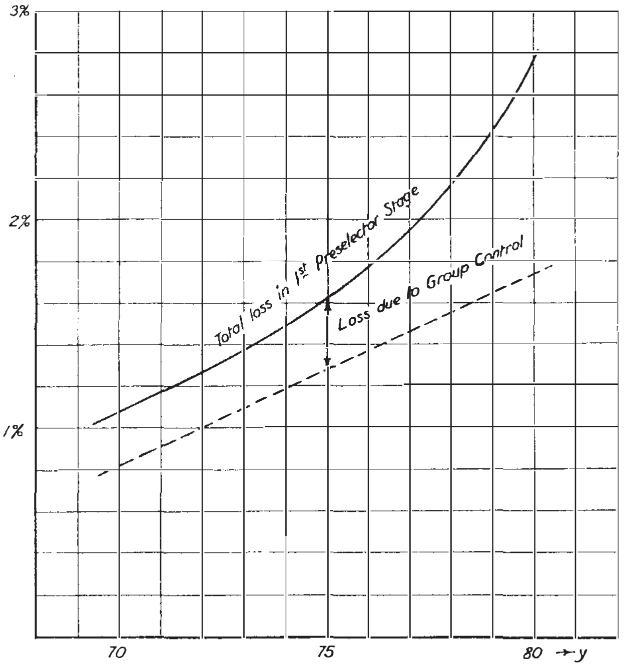


FIG. 3 Loss in the 1st Preselector Stage showing the effect of Group Control.

The author concludes that with large traffic densities, it will be economical to use greater numbers of contacts than 10 on first preselectors.

With small traffic densities, a 10-contact field is suitable. He notes, however, that the whole question turns on economical values and the question of standardisation.

Notes on the above theory.

(1) There are two drawbacks to the practical use of this theory—

- (*a*) The calculations are very lengthy, even though several terms in the various series may be dropped as the values fall.
- (*b*) A new formula must be constructed for W_{r_x} for every different arrangement of cross-connection.

(2) The Poisson formula has been used throughout, which is not strictly correct, as the number of circuits is not unlimited, though it is fairly accurate for large numbers of switches.

(3) This formula does not apply, as stated before, to the case of homing preselectors.

(4) It is not thought that Lubberger's' formula (Equation 10) is theoretically sound, when used in the way Baltzer uses it, and thus, the use of Erlang's would be preferable, in its place.

A small 100 hours artificial traffic test was made, assuming 3-contact first and second preselectors, 6 groups of the former, and 3 of the latter, as a severe test (owing to the small number of switches, etc.).

In this test, a total value of 3 traffic units was taken, for which value Erlang's and Poisson's formulæ give approximately the same results.

The resultant theoretical and practical values of P_x are shown below.

	P_0	P_1	P_2	P_3
Artificial Traffic Result	0.8819	0.1044	0.0127	0.0011
Theoretically	0.8643	0.1161	0.0153	0.0027

These results compare very well, under the circumstances.

Further work by Baltzer.

This author in later numbers of the same journal deals with several of the associated probability problems.

In one of them ("Zeitschrift Für Fernmeldetechnik," September and October, 1928), he treats the question of double preselector schemes in which some of the first preselector outlets are connected directly to the first selectors, the rest being connected *via* second preselectors. A simple 2-group grading of the trunks to second preselectors is also introduced, though its effect does not form part of the calculations.

A formula for the probability that x of the 10 outlets from a group of 50 lines are engaged by group control is given, which, though interesting, does not seem to be of much practical use at present, owing to the fact that doubtful assumptions are made which a practical test might show to be quite inaccurate.

In a further article ("Zeitschrift Für Fernmeldetechnik," November, 1928) Baltzer deals with the law of the distribution of holding times. He suggests a Gaussian Law foundation with origin moved to the left, and with an additional peak due to very short calls.

The Gaussian Law would suggest that the holding time denoted by the peak of the curve (*i.e.*, excluding the very short calls denoted by the sharp peak) is such that the numbers of calls having greater and smaller holding times are equal.

The Law hitherto used by several is of the form $\phi(u) = e^{-u}$ where u = holding time.

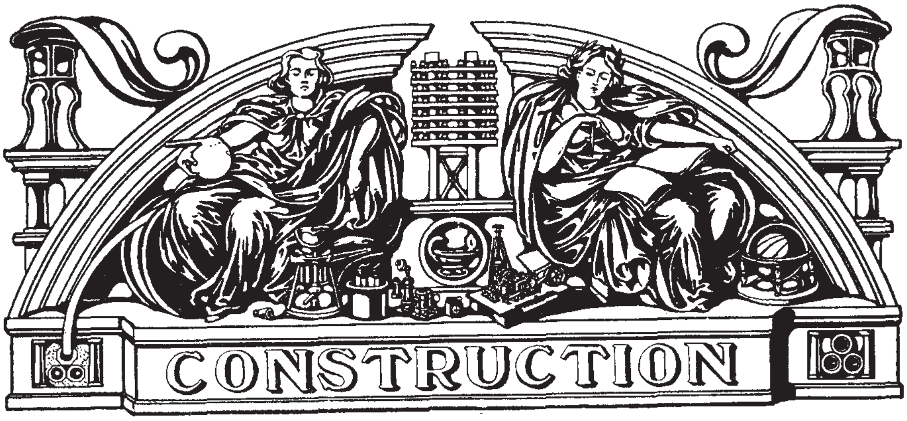
H. T. W. Millar.

[*A copy of this article was sent to Dr. Baltzer before publication, when he made the following comments*:—

(*1*) *He has found a simple method of calculating the values of* P_z *which he intends to publish in detail in a future article.*

(*2*) *While he agrees that the Poisson formula is unsuitable to the extent suggested in the article, he considers Erlang's formula equally so.*

(*3*) *He considers that Lubberger's formula* (*10*) *is fundamentally right, but states that he hopes to publish in the future a new loss formula which will be correct for large and small values of traffic.*]



THE HOLBORN GAS EXPLOSION.

O. P. Moller, A.M.I.E.E.

When, in 1862, a Company called the Pneumatic Dispatch Coy. constructed a tube between St. Martins-le-Grand and Euston Sation for the purpose of conveying parcels between those points, the promoters little dreamed of the amazing happenings that, 66 years later, would centre about that portion of their tube which lies—or did lie until recently—between Kingsway and Tottenham Court Road.

On a bleak morning in December last a section, three eighths of a mile long, of one of London's main thoroughfares was, within a few minutes, converted from a solidly built and level roadway into a chaotic ruin of tilted flagstones, upturned blocks of concrete, cavities and fissures, leaning lamp-posts and zig-zag kerbs. Heavy manhole covers were shot high into the air and during the explosions the whole roadway rose and fell with a wave-like motion. A taxi-cab was overturned, windows were broken and underground cellars blown in. Flames broke out at many points and the terrified onlookers might have been pardoned for refusing, on this occasion, to believe their senses. Even the

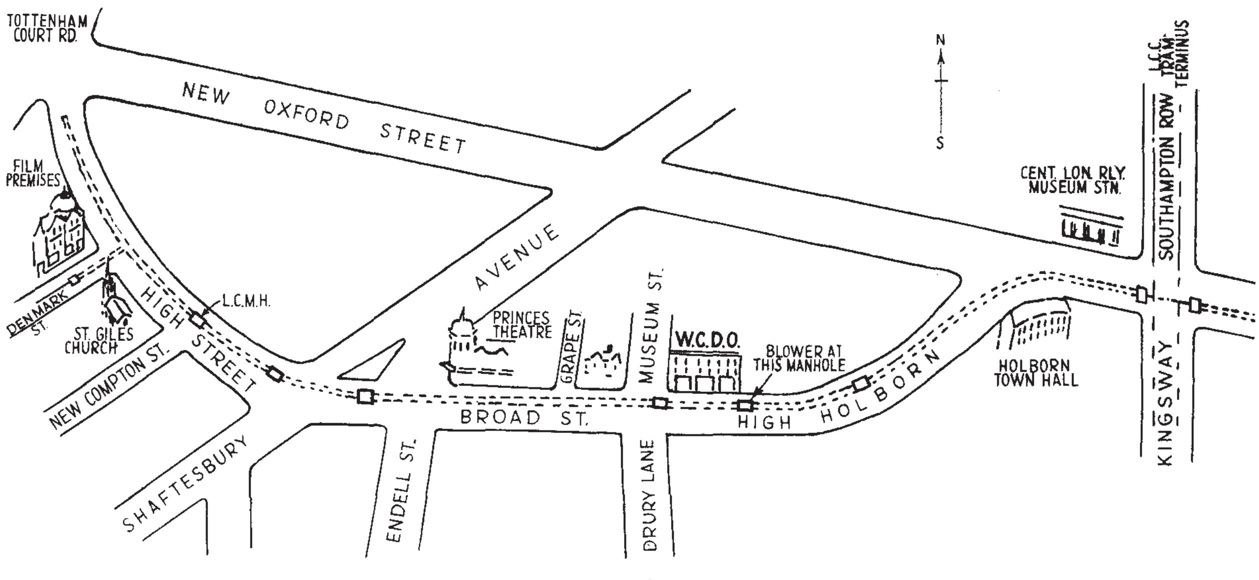


Fig. 1.—Plan of Tube Route.

newspaper reporters were unable to do much more than report the solid truth!

The old parcels tube, as it is called, in which the gas that did the mischief seems to have collected, was built of cast iron lengths, of "D" section, jointed with lead and yarn, the flat part forming the floor and the upper portion the arch. The tube is 4′ 6″ wide and 4′ 3″ high. It carries only Post Office cables and these are arranged on either side with a gangway down the centre. A detailed description of the tube is given by Mr. H. R. Kempe in Paper No. 32, "Pneumatic Dispatch," Institution of P.O. Electrical Engineers.

The history of the tube is interesting. Built, as has been said, in 1862, it was abandoned after two or three years' working on account mainly of the difficulty of keeping it airtight. It lay derelict until 1921, when the local authorities having control of the streets traversed suggested to the Post Office authorities that if underground cables were required in those streets they should be laid in the derelict tube. Owing to the congestion of traffic in Holborn, it was desired that this thoroughfare, especially, should not be opened up. The Post Office considered the possibilities of the tube as an underground cable route and ultimately decided to purchase it, the owners having been traced. From that time cables have been laid in various sections, and in the half-mile section between Kingsway in Holborn and Tottenham Court Road there were approximately 26 cables in use when the explosion occurred in this length in December last.

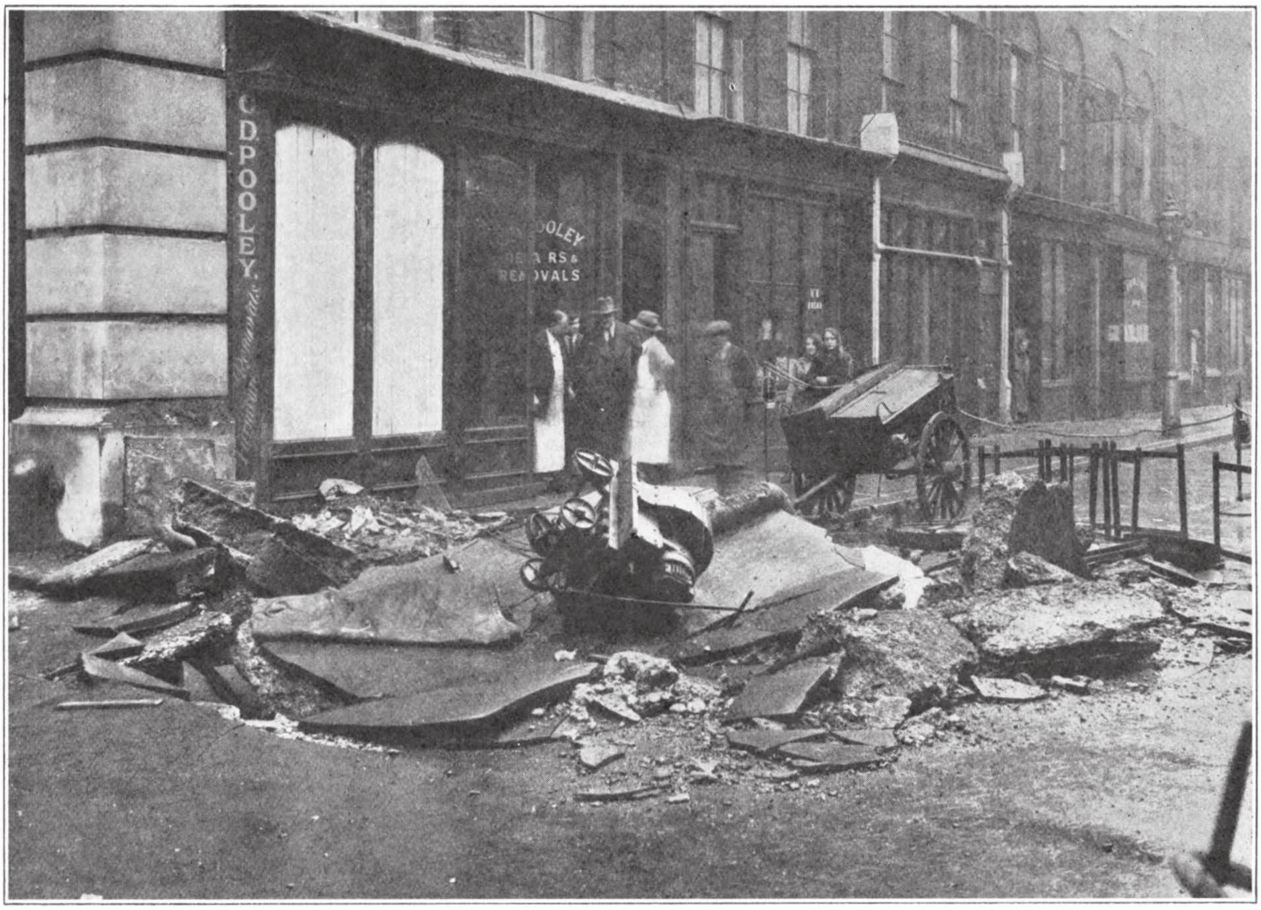


Fig. 2.—Outside Manhole where first explosion took place.

For purposes of access, drawing in cables, jointing, and housing loading coils, a number of manholes had been constructed at intervals. These are indicated on plan in Fig. **1**.

It was found that gas, on occasions, accumulated in certain portions of the tube and in order to remove this the Post Office found it necessary to install electric blowing plant for the purpose of pumping in fresh air at one manhole while adjacent manholes were opened to let out the gas. This blower was worked from power points arranged in connection with circuits provided for lighting the tube.

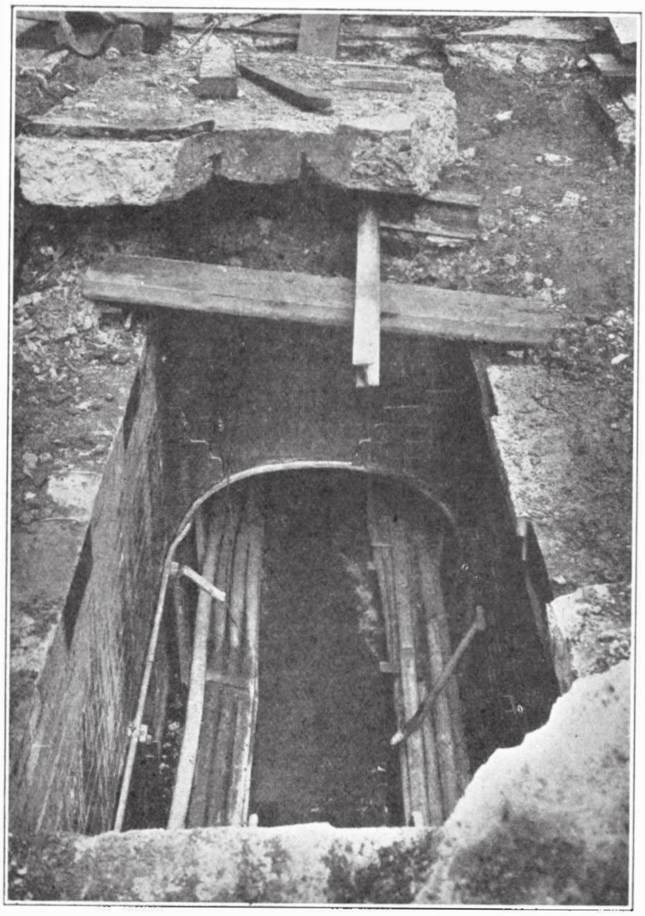


Fig. **3**.—Interior of Manhole after roof had been removed.

At 7.45 a.m. on the morning of Thursday, 20th December, 1928, Post Office workmen arrived at the manhole near the West Central District Office and made preparations for blowing-out preparatory to entering the tube. A smell of gas was noticed as soon as the manhole was opened. One of the men went down with the lead, but before he could connect it an explosion occurred in the tube, and before he could get up the ladder and out of the manhole another explosion occurred. While he was head and shoulders out of the manhole this second explosion blew him out on to the roadway in flames. He died 10 days later in Charing Cross Hospital.

Gas mains and water mains were fractured, and as a result of the gas escaping a further explosion took place about 12.30 a.m. at the end of Denmark Street in High Street, setting fire to a building occupied by firms in the cinema film trade, and although a very large number of fire engines were on the site the building was burned out in a very short time.

Fig. **1** is a plan of the area concerned.

Fig. **2** shows the manhole at the rear of the W.C.D.O. where the first explosion took place.

Fig. **3** shows the interior of the manhole outside W.C.D.O. immediately after the roof and debris had been removed. An iron ladder normally rested in the centre of the wall facing the photographer.

Fig. **4** shows the roadway outside the Princes Theatre.

Fig. **5** shows the Gas Light & Coke Co.'s excavation outside the Princes Theatre, where repair work on a 48″ High Pressure Gas Main had been carried on.

Fig. **6** shows an 8″ bend on the gas main, which was over 40 years old. The metal, which was thick on the inside of the bend, had run out thin on the outside and the hole, showing black, in the fore-ground was 1½″ long by 1″ wide. On the broken pipe next to the bend was a ½″ hole in thin metal. With a pocket knife blade it was possible to make another hole close by. On breaking off a piece of the cast iron it was possible to cut it easily with an old pocket knife as in the locality of the break it was composed partly of graphite.

Fig. **7** shows the wrecked roadway with Loading Coil Manhole opposite New Compton Street in High Street.

It has been decided to rebuild the destroyed route in standard octagonal duct work, the whole of the partly destroyed iron tube being taken out.

The remaining portions of the old tube between St. Martins-le-Grand and Kingsway and between Tottenham Court Road and Euston Station are still in use.

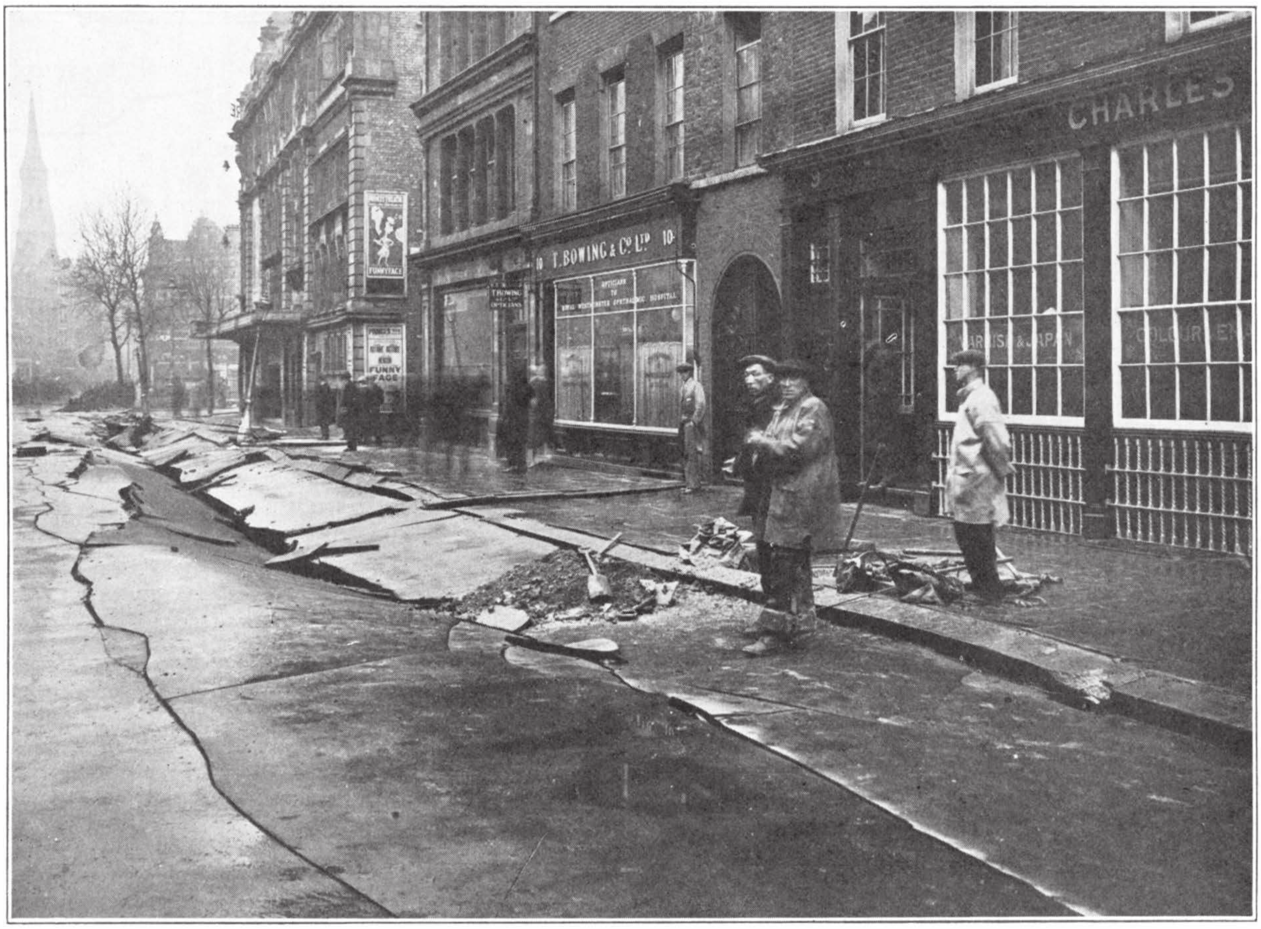
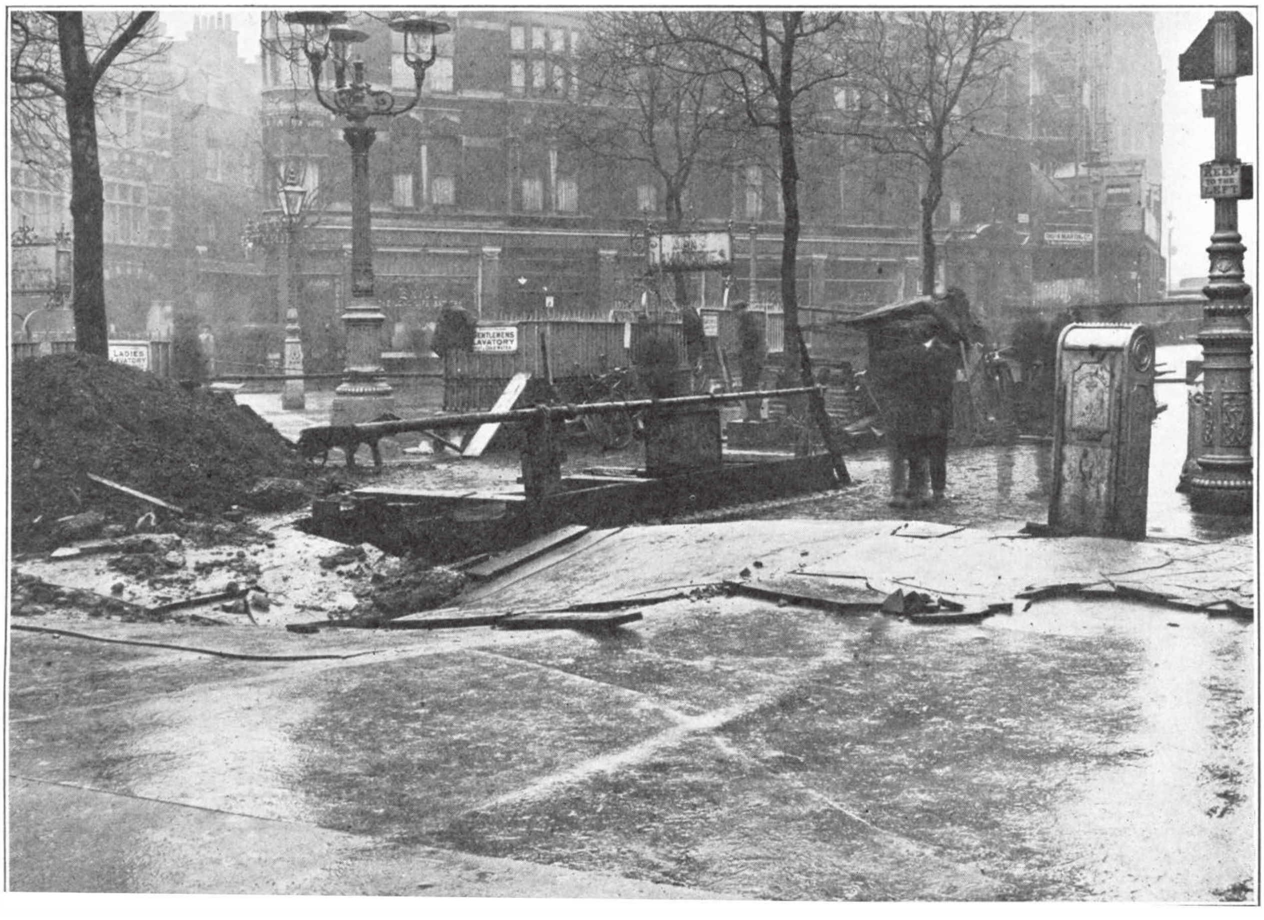


Fig. 4.—Roadway near Prince's Theatre.



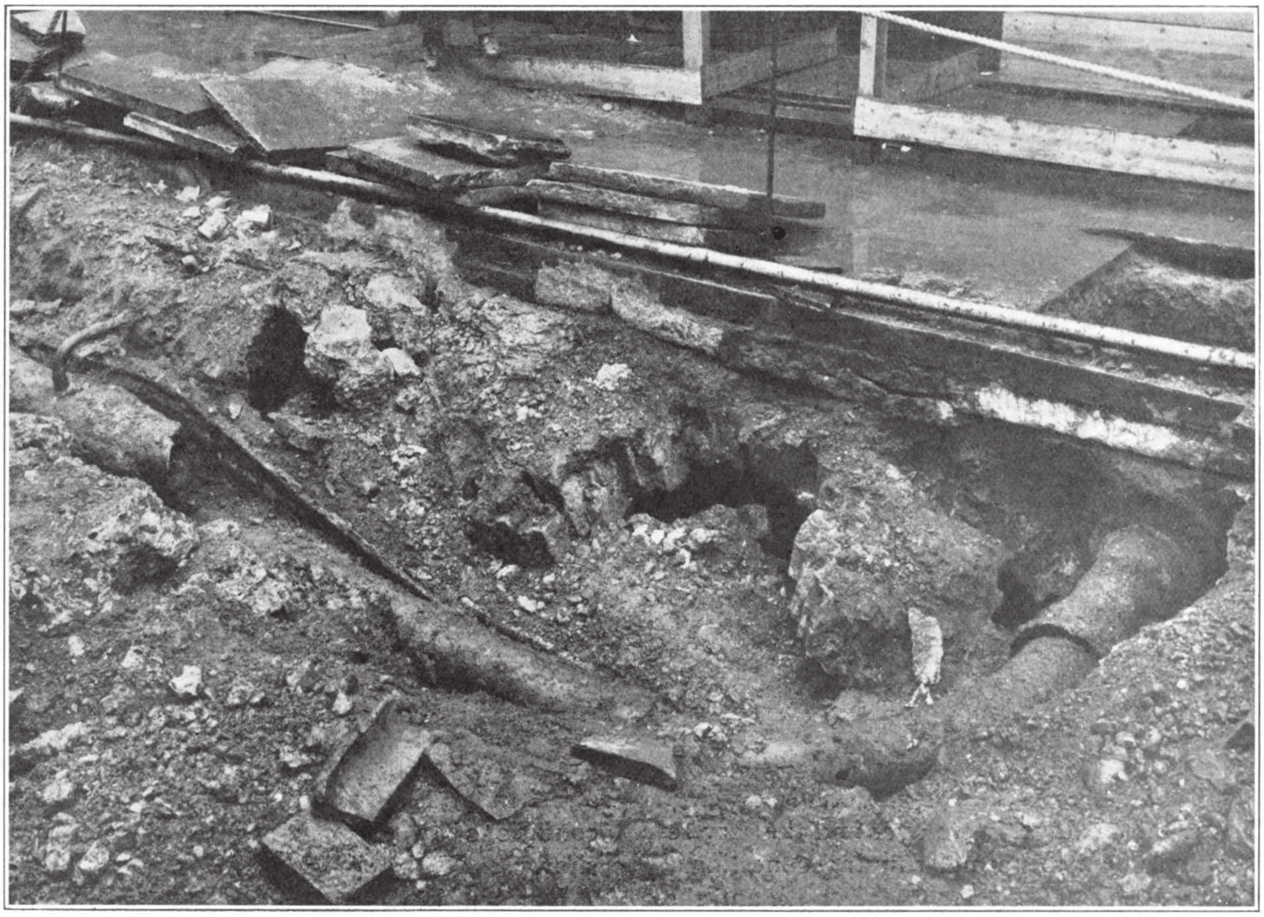
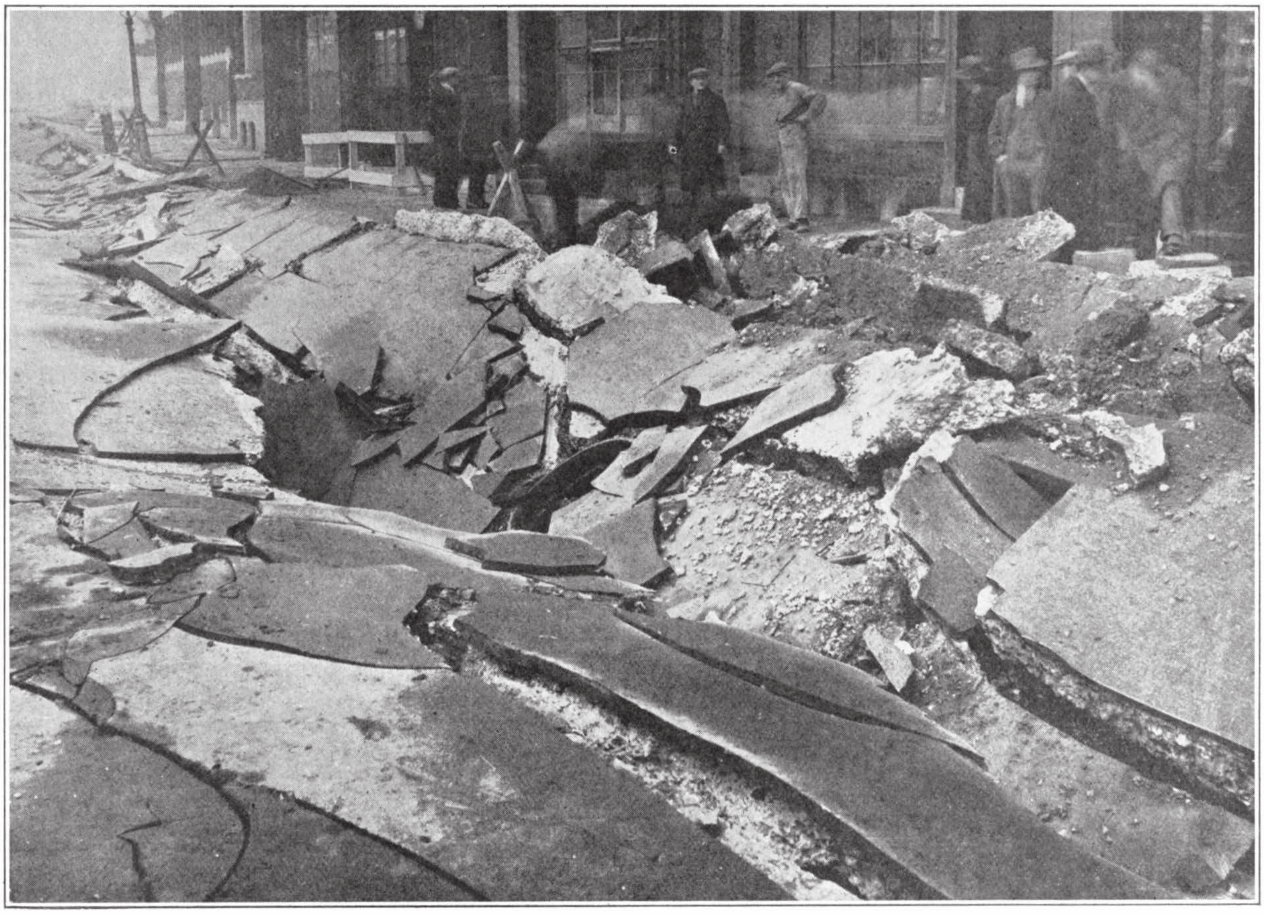
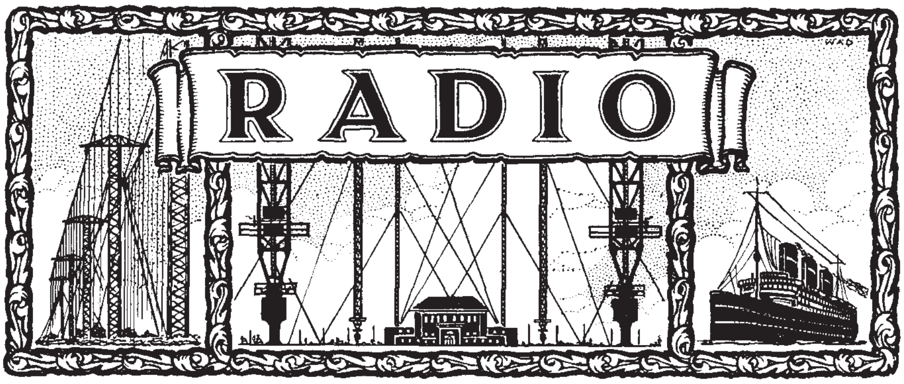


FIG. 6.—BEND ON GAS MAIN.





VARIATIONS IN SIGNAL STRENGTH FROM AUSTRALIA.

THE Australian Beam service was opened for traffic in April, 1927, the wavelength used by the Australian transmitter being 25.728 metres or 11,660 kilocycles. After the initial stages were over and the service had settled down to normal running conditions, systematic records of the signal strength and the conditions existing on the service were instituted.

These records were commenced in June, 1927, and sufficient time has now elapsed to show that the variations in signal strength apart from magnetic storms and other irregular interruptions are cyclical.

The method adopted for keeping these records is for the attendant on the receiver at Skegness to record hourly his impressions of the signal strength at the first listening position on the receiver, allowances of course being made for the couplings, etc., in use at the time so that the values obtained are entirely empirical. These hourly readings are plotted daily on a time basis, the signal strength being graded from 0 to 6, one chart being used for one month's readings. At the end of the month there are thus 30 or so readings at each hour; these are evaluated and a curve constructed from the results obtained. This curve represents the average value of the signal strength at each hour of the day for that month. The series from June, 1927, to July, 1928, are shown in full line in Fig. 1, those for June, 1928, to November, 1928, being shown dotted. The curve for December, 1928, has been omitted as changes were made in the Australian transmitter during that month which had the effect of increasing the received signal strength at Skegness. The daylight darkness conditions on the great circle paths are also shown.

During January good signal strength is obtained from 0900 till 1800 with a slight diminution at 1100. The gradual weakening of signals at 1100 and the increasing time during which this weakening is experienced can be seen through February, March, April and May until its maximum is obtained in June and July. Thereafter this gap closes up gradually until January, when it has again almost disappeared. In the same way the growth and decline of signal strength during the evening and early morning periods can be seen to repeat over each year.

The Australian service is worked on two routes, westward from England from approximately midnight till noon, and eastward from England during the remainder of the day. These two great circle paths differ in length, the westward or long route being about 23,000 kilometres, and the eastward or short route about 17,000 kilometres.

Sunrise and sunset do not show any effect on the average signal strength when the service is worked on the long route. Any possible effect is masked by the fact that the sun has risen in Australia before it has set in England on this route.

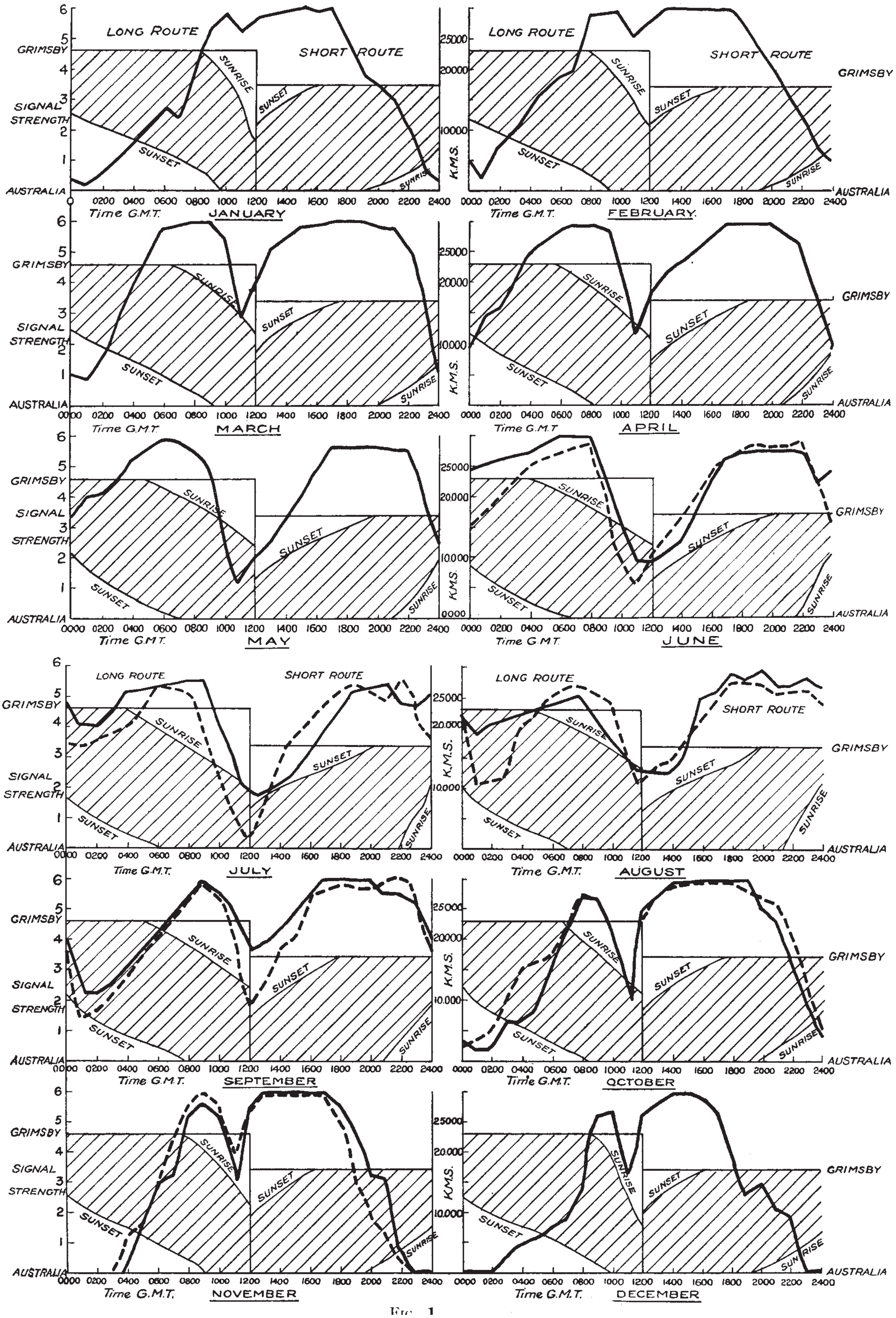

LONG ROUTE
SHORT ROUTE
GRIMSBY
AUSTRALIA
SIGNAL STRENGTH
SUNRISE
SUNSET
K.M.S.
25000
20000
10000
0
1
2
3
4
5
6
0000 0200 0400 0600 0800 1000 1200 1400 1600 1800 2000 2200 2400
Time G.M.T.
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

Fig. 1.

A slight weakening of signals is, however, noticed at Skegness at the English sunrise, but the effect only lasts for a short time so that the average strength curves are not seriously affected.

The Australian sunrise on the short route does, however, have a very marked effect on signal strength at certain periods of the year. This effect is definitely seen in each month, except May, June, July and August; even in these months it may be the cause of the slight drop in signal strength noticed about this time, but, as the English sunset occurs about the same time, it is difficult to establish definitely whether the former or the latter is responsible, especially in view of the peculiarity observable with the Australian sunrise in other months. In January the effect of the sunrise is noticeable two hours before the sun actually rises at the transmitting station. In February the period is also two hours, but in March it is one hour, in May half an hour, in September and October it is again half an hour, increasing to one hour in November and two in December.

This appears to be a peculiar effect, but in the light of experience obtained on the Indian beam service it is suggested that an explanation may be found in the difference existing in night conditions in winter and summer. On the Indian service a 16 meter wave is used for daylight communication, and it is found that, during the winter, signals fade out, at the latest, two hours after sunset in India; that is, after there is more than two hours of darkness on the path. In summer, however, this period is extended and it frequently happens that good signal strength is

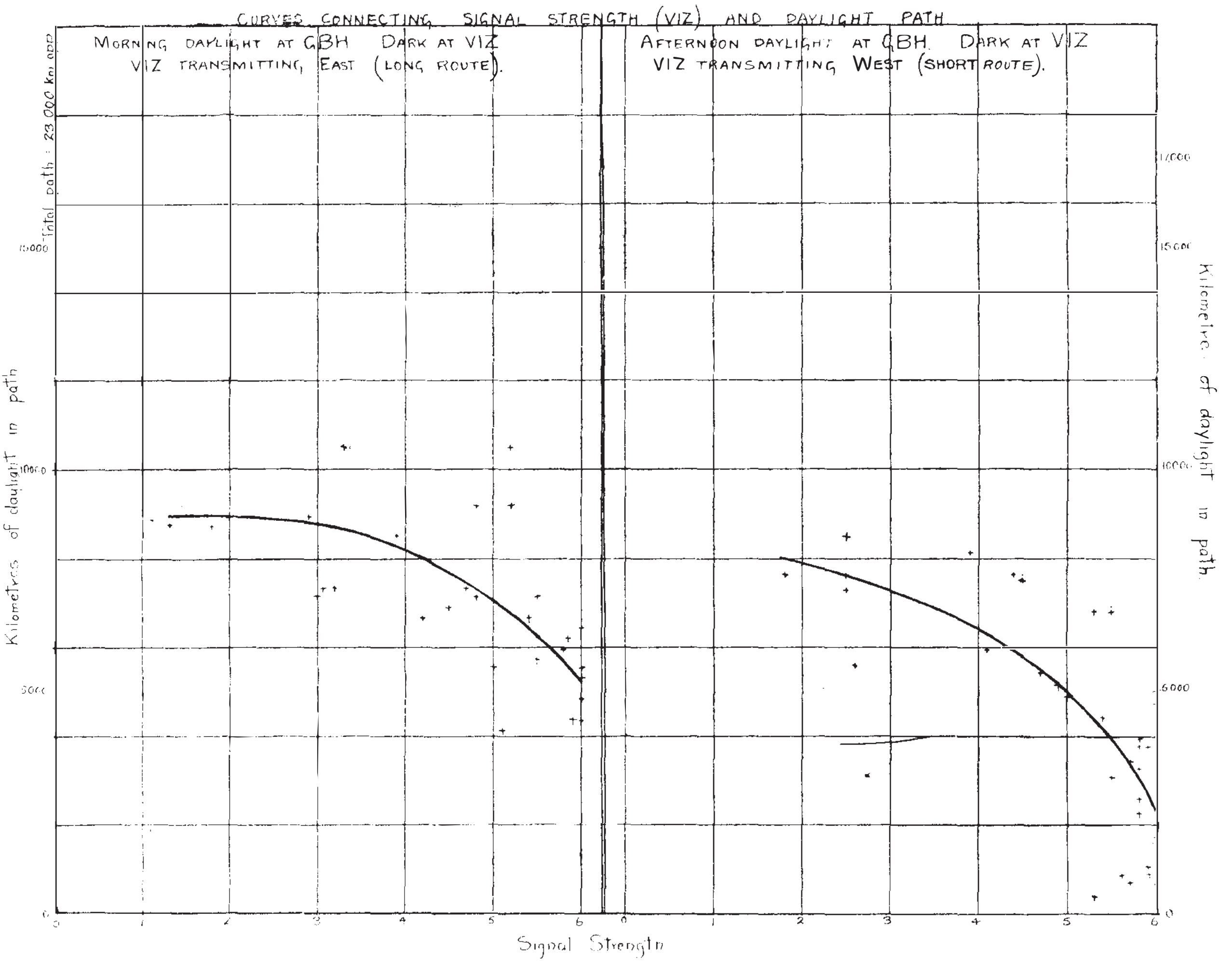


FIG. 2.

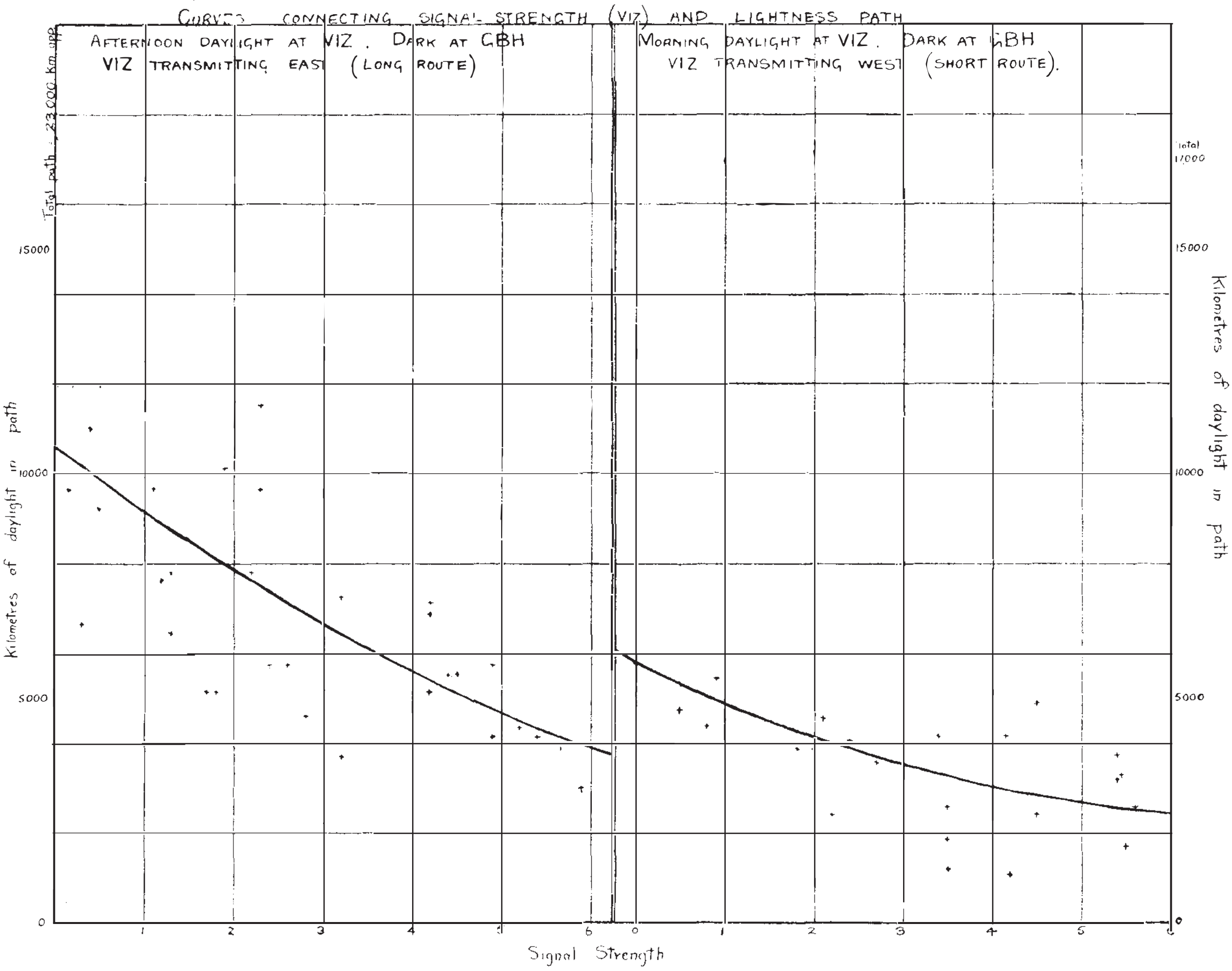


FIG. 2.

obtained when the whole of the path is in darkness. This would suggest that for some distance at least on the dark side of the daylight-darkness path the summer night conditions obtaining on the Heaviside layer approach day conditions. Night conditions approaching day conditions would thus obtain on the great circle path for some time before actual sunrise at the Australian transmitter and would produce a diminution in signal strength, as the wave used is primarily a darkness wave. This effect is apparent on the Indian service in summer and it would consequently appear to be due to the altitude of the sun; therefore the premature sunrise effect on the Australian service should be at a maximum during the Australian summer, as is actually the case.

There are four daylight-darkness conditions obtaining on this service; two on the long route and two on the short route. In the former there is, firstly, afternoon daylight at Australia and darkness in England and, secondly, darkness in Australia and morning daylight in England. In the latter there is, firstly, afternoon daylight in England and darkness in Australia and, secondly, morning daylight in Australia with darkness in England. From a first inspection of the average curves, it is apparent that the effects of these four conditions are not similar, and curves connecting the length of the path in daylight with the signal strength obtained under the four conditions, are shown in Fig. **2**. There appears to be a very marked difference in the effect of morning daylight at Australia when compared with the other three conditions, the attenuation of signals being much greater, even though this condition occurs on the short route. Signal strength fades from maximum to zero when—

1. The daylight path length is increased by 3,500 kilometres with morning daylight in Australia.
2. The daylight path length is increased by 7,000 kilometres with afternoon daylight in Australia.
3. The daylight path length is increased by 6,000 kilometres with afternoon daylight in England.
4. The daylight path length is increased by 4,000 kilometres with morning daylight in England.

Maximum signal strength is obtained when—

1. Under 2,500 kilometres of the path is in daylight under morning daylight conditions at Australia.
2. Under 4,000 kilometres of the path is in daylight under afternoon daylight conditions at Australia.
3. Under 5,000 kilometres of the path is in daylight under morning daylight conditions at England.
4. Under 3,000 kilometres of the path is in daylight under afternoon daylight conditions at England.

These curves are average curves and of course take no account of seasonal variations, which, it is well known, have a marked effect on the attenuating effect of daylight.

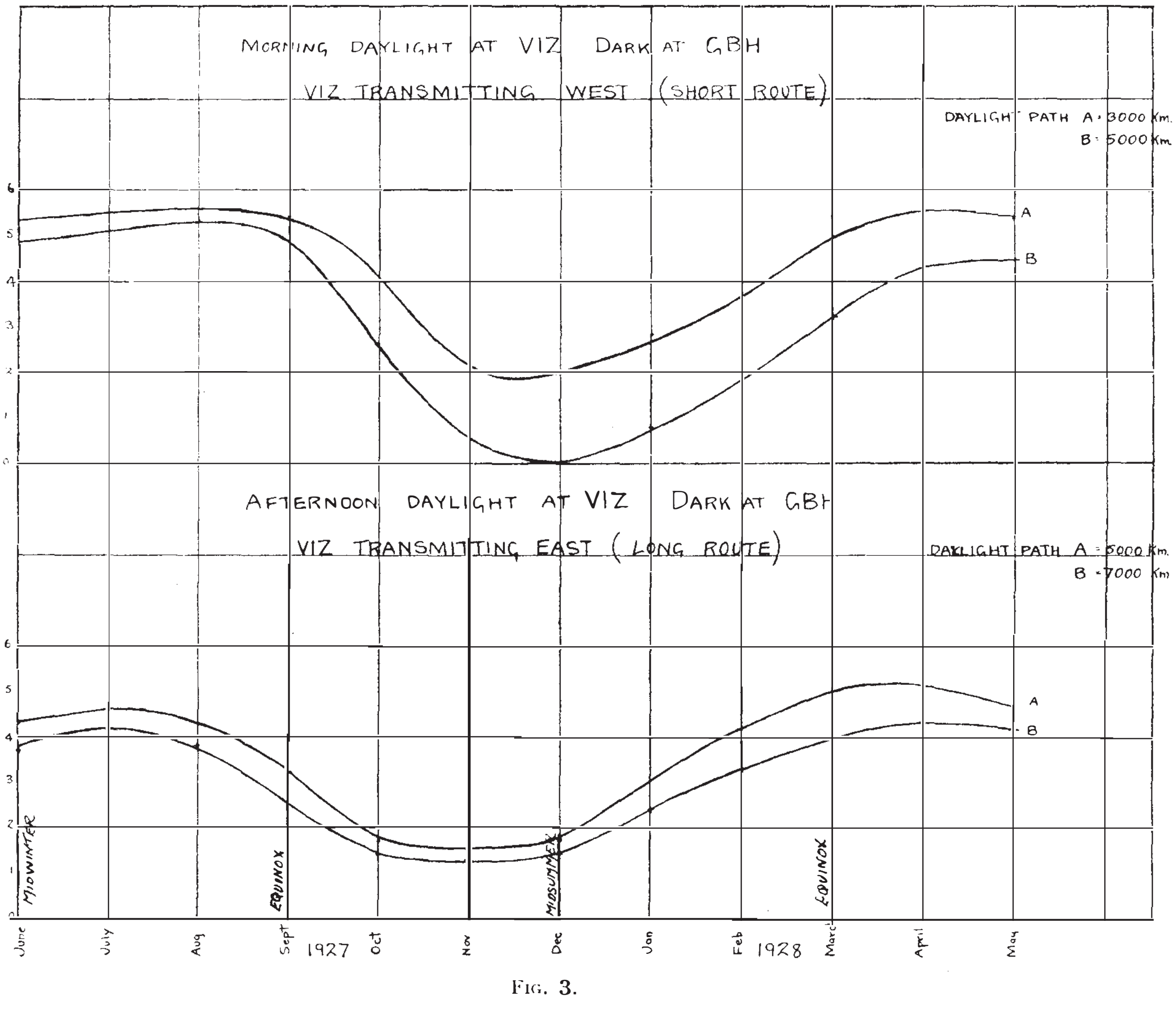


Fig. 3.

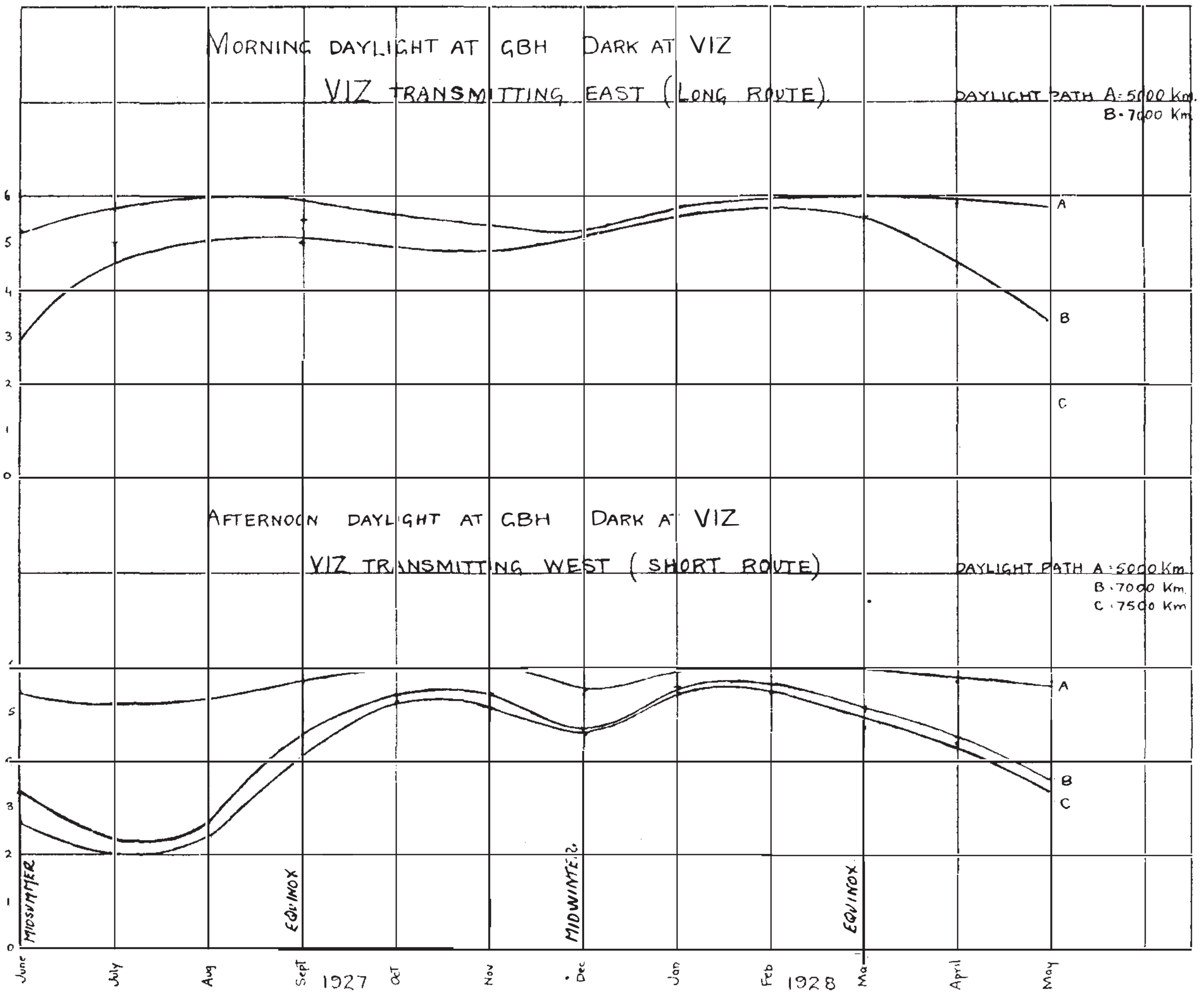


FIG. 3.

To show this seasonal effect the curves shown in Fig. 3 have been prepared. In these curves the signal strength obtained with a definite amount of the path in daylight under the four different conditions have been plotted on a monthly basis. With afternoon daylight at Australia on the long route, the greatest signal strength is obtained in the Australian winter, April to July, falling to a minimum during the Australian summer. This curve is fairly symmetrical about these two seasons.

The curve for the Australian morning daylight shows a greater signal strength in the Australian winter and a smaller strength in summer than the corresponding curve for Australian afternoon daylight, and the strength falls rapidly to the summer condition during the spring, but only rises slowly during the autumn.

The curves for the English daylight conditions show no serious change in signal strength for the shorter distances under winter and summer conditions, but definite minima occur at the English summer on the longer distances. The curves also appear to be fairly symmetrical.

There is considerable difference in the attenuation produced under the differing daylight and seasonal conditions and the figures have been tabulated to show those differences. The Australian figures have been rearranged so that a direct comparison between similar seasonal conditions at both ends of the service may be made.

Length of Light Path 5000 Kilometres.

English.			Australian.		
Month	Morning daylight (long route)	Afternoon daylight (short route)	Month	Morning daylight (short route)	Afternoon daylight (long route)
Jan.	5.6	5.9	July	5.1	4.6
Feb.	5.9	6.0	Aug.	5.3	4.3
Mar.	6.0	6.0	Sept.	4.9	3.2
April	5.9	5.8	Oct.	2.5	1.8
May	5.7	5.6	Nov.	0.5	1.1
June	5.2	5.4	Dec.	0.0	1.8
July	5.7	5.2	Jan.	0.7	3.0
Aug.	6.0	5.5	Feb.	1.7	4.2
Sept.	5.9	5.7	Mar.	3.2	5.0
Oct.	5.4	6.0	April	4.3	5.1
Nov.	5.3	6.0	May	4.5	4.8
Dec.	5.2	5.5	June	4.9	4.4

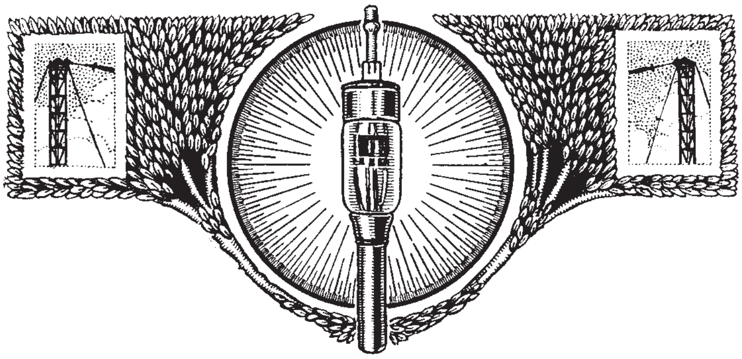
Length of Light Path 7000 Kilometres.

Jan.	5.5	5.5	July	no figures	4.1
Feb.	5.8	5.6	Aug.		3.8
Mar.	5.5	5.1	Sept.		2.5
April	4.5	4.5	Oct.		1.4
May	3.3	3.6	Nov.		1.2
June	3.0	3.3	Dec.		1.4
July	4.5	2.3	Jan.		2.4
Aug.	5.0	2.7	Feb.		3.3
Sept.	5.0	4.5	March		4.0
Oct.	4.9	5.4	April		4.3
Nov.	4.8	5.4	May		3.8
Dec.	5.1	4.6	June		4.1

These figures show that, under similar seasonal conditions, daylight at the Australian end has a worse effect on signal strength than daylight at the English end. Unfortunately, similar figures for the English transmissions to Australia are not available, so that it is not possible to say whether daylight at the transmitting end of a service has a greater attenuating effect than daylight at the receiving end, or whether the effect of Australian daylight on signals received there would show the same greater attenuation when compared with English daylight. If the latter be the case, it may be that the differing latitudes of the two stations is the deciding factor.

In all these curves the readings an hour before the normal route changing times of noon and midnight have been omitted as this change is not made exactly at the specified time throughout the year.

R. G. DE WARDT.



NOTES & COMMENTS

IN the New Year's Honours List, the issue of which owing to the regrettable illness of His Majesty the King had been postponed till March 1st, every officer in the P.O. Engineering Department and his numerous friends outside the service were delighted to see in the list of Knights Bachelor the name of Colonel Thomas Fortune Purves, O.B.E., Engineer-in-Chief of the Post Office. Since 1922, the year in which he was appointed to the Chief's chair, Colonel Purves has been responsible for many developments in the art of electrical communications, a few of which may be enumerated here: Completion of Trunk underground cable and repeater station system; introduction of lead-covered paper-core loaded submarine telephone cables to the Continent; Trans-Atlantic Radio Telephone Service, which now covers all North America and practically all Europe except Russia and Turkey; the Beam Radio Services to India, Australia, South Africa and Canada: the extension of Automatic telephone service to many industrial and residential centres in the provinces and an excellent and promising start made with the conversion of the London system to Automatics; the opening of the London P.O. Tube Railway, etc. Such are a few of the achievements carried out by the Department over which the new knight has presided with his customary grace and skill for some six years, and surely he thoroughly deserves the honour the King has bestowed upon him and indirectly bestowed upon the Department he represents.

Of his work before 1922, we would refer our readers to the July, 1922, issue of this Journal. The appreciation given there terminates as follows:—"The staff has received the announcement of Major Purves's appointment as their chief with unanimous approval and the keenest satisfaction. Their confidence in his scientific and engineering ability and in his established reputation as a broad-minded and sympathetic administrator will act as an effective inducement to all to place their best efforts at the service of the Department, and foster the feelings of mutual trust between the staff and the Administration without which it is not possible under present day conditions to carry on a great industrial concern efficiently and satisfactorily. The new Chief is a strong man—literally, and in the later meaning of the word—and with an immense enthusiasm for his profession. Yet withal he is ever genial and kind-hearted. For the past twenty years, during which period the writer has been closely associated with him, he has never been known to lose his temper with a subordinate." And still, despite alarums and excursions, setbacks and triumphs, overwork and worry, he remains the same. We are sure we express the wishes of every member of the staff when we offer here our heartiest congratulations to the Engineer-in-Chief upon the well-earned honour now conferred upon him.

THE P.O. COMMERCIAL ACCOUNTS, 1927/8.

The contents of this valuable annual publication can best be summarised from the Explanatory Memo, which appears after the contents page. "The accounts bring together the revenue, capital expenditure and operating expenditure from the various accounts and returns in which they are accounted for to Parliament. The cash figures so obtained are adjusted to the income and expenditure basis, except where the variation is unimportant. Provision is made for the reserves for depreciation, pensions, etc., which are necessary to exhibit the commercial results of operation. Interest is charged on all loan capital or moneys treated as loan capital. In addition to the General Account for the P.O. as a whole, separate accounts are prepared for the three main services, postal, telegraph and telephone. . . . The surplus or the deficit on the year's working is regarded as paid to the Exchequer or made good by the Exchequer, as the case may be, and is not carried forward to the next year's account."

The capital assets of the P.O. consist of—

(*a*) Engineering plant and stores for the telegraph, telephone and electric light, etc., services.
(*b*) Land and buildings.
(*c*) P.O. (London) Tube Railway.

Smaller assets are charged against revenue as they are purchased.

The total capital liabilities shown in the Balance Sheet under General Account are given as £124,548,488, and are made up of (*a*) Loans raised under the Telegraph Acts 1892 - 25 £69,045,374; (*b*) Exchequer Bonds £1,179,900; (*c*) Exchequer Advances £48,179,373 and (*d*) Sundries £6,143,841. The total Telephone Capital raised to date amounts to £99,699,482, but of this amount £31,562,384 has been redeemed. The interest payable on this capital has varied from 3½ per cent. in 1913, up to 6 per cent. in 1921/22 and in 1928 5 per cent.

The certified assets in the above Account are as follows:—

	£
Freehold Land and Buildings ...	17,510,781
Leasehold ,, ,, ,, ...	1,439,073
Plant	96,501,600
Engineering Stores in Stock ...	3,241,688
Sundry Debtors for revenue ...	3,296,284
Cash: On Revenue A/c and Subscribers' Deposits ...	2,559,064
	£124,548,488

After making provision for depreciation, pensions, and interest on capital the accounts show a loss of £1,380,829 on Telegraphs and a profit of £107,391 on Telephones for the year.

It might be stated here that the prospects of an increase in Telephone profits are distinctly favourable for this year.

TELEPRINTERS.

In an article on the possibilities of Teleprinters for public use in the *Telegraph and Telephone Age* of January 1st, 1929, Mr. E. Kleinschmidt finds Europe progressive in matters telephonic but that it lags behind America in telegraph practice. Nevertheless he admits that Europe had seen the possibilities of the adoption of the Teleprinter system and is endeavouring to establish subscribers' exchanges for inter-communication by the use of Keyboard Telegraph apparatus. Such a system has been provided for the use of the Berlin police on a fairly large scale.

The German Telegraph administration is also interested in telegraph exchange systems, and they have plans in hand for the supply of a public service.

The French Telegraph Administration has started a Teleprinter Exchange known as the "Telemixte." This is fully described in *Le Matin* of September 1st, with costs for rental and calls. The system operates on a telephone subscriber's circuit, but is not planned for simultaneous telegraph and telephone working. The subscriber asks for a teleprinter connection by phone and switches over to his telegraph instrument.

The British Post Office is also considering the matter.

The High Commissioner for Canada in London has communicated the following paragraphs prepared by the Canadian Government Information Bureau at Ottawa:—

CANADIANS THE GREATEST TELEPHONE CONVERSATIONALISTS IN THE WORLD.

Canadians are the world's greatest telephone conversationalists. A recently issued official bulletin dealing with telephone statistics shows that on a per capita basis an average of 221 conversations per year were held by the people of Canada, compared with 205.4 in the United States, the next highest, and 137 in Denmark, which is given third place.

The bulletin shows that there were at the end of 1927 a total of 1,259,987 telephones in Canada, an average of about one 'phone for every eight persons in the Dominion. Canada has 2,462 telephone system with a wire mileage of 3,591,035. The Province of Ontario leads in the number of 'phones with 558,468, an average of 17.5 per 100 of population. Quebec is next with 255,970, an average of 9.8 per 100; then British Columbia with 113,051, or 19.7 per 100; Saskatchewan 107,782, or 12.9 per 100; Manitoba 74,032, or 11.4 per 100; Alberta, 73,407, or 11.9; Nova Scotia, 41,219, or 7.6; New Brunswick, 31,254, or 7.6; Prince Edward Island, 4,669, or 5.4, and the Yukon Territory, 136, or 3.9 per 100 of population.

FURTHER TELEPHONE EXPANSION IN EASTERN CANADA.

The Bell Telephone Company of Canada contemplates an expenditure of $27,000,000 during 1929 on construction and expansion of facilities on its lines in eastern Canada. This will be the largest appropriation in the history of the Company, comparing with $22,000,000 for the current year, which in turn was $4,000,000 larger than the 1927 amount.

Of the $27,000,000 for next year, $7,000,000 will be for extending long distance lines, including expenditures on new carrier current facilities, new cables, etc. Part of the total is for the new headquarters building in Montreal, which will be ready for occupation in five or six months. Eleven major building projects are under way.

OVER 250,000 RADIO LICENCES IN CANADA.

More than a quarter of a million Canadians holding radio receiving sets had paid the Government tax of $1 up to the end of November, 1928, an increase of 17,000 as compared with the end of November, 1927.

The returns indicate that there are 226,240 private radio receiving licences, although it is believed that more than 100,000 sets exist on which no license has been issued. The revenue from the issue of licenses is devoted by the Department of Marine and Fisheries to the improvement of radio services, about a score of radio interference cars being in use.

We regret to record the death of Mr. C. W. V. Schaefer, M.I.E.E., Electrician-in-Chief of the Eastern Associated Telegraph Companies. Mr. Schaefer entered the service of the Eastern Telegraph Company as a probationer at Malta in September, 1884, his father being in the service of the company at that station. In 1887, Mr. Schaefer was transferred to Gibraltar, remaining there until 1890, when he joined the electrical staff of the cable-ship "Electra." He subsequently served afloat in the cable-ships "Chiltern, "Great Northern," the old "Mirror," "Amber," and the "John Pender," in which ship he took over electrical charge from Mr. F. Ryan in February, 1902. Mr. Schaefer left the cable-ship "John Pender" upon his appointment to the H.O. Staff in April, 1906, and was promoted to the position of Electrician-in-Chief upon Mr. F. Ryan's retirement in March, 1923. The long practical experience in cable construction, laying and repairing, gained by Mr. Schaefer especially fitted him for his position as head of the department responsible for this work, and he was a recognised authority on cable engineering in all its branches. The benefit of this experience, too, is reflected by the utility of his various tests for the localisation of breaks and faults in submarine cables, the well-known "Schaefer" break test being practically universally adopted by the cable community at large, and he leaves behind most valuable data in the field of cable engineering.

Electrician-in-Chief of the Eastern Associated Telegraph Companies for six years, he was instrumental in arranging for a complete change in the method of cable working over the very large network of cables controlled by them. The introduction of the Regenerator revolutionised cable working, all in this relatively short period. The first trials were not completed until 1924. Up to that time it was unsatisfactory to work with more than two relay stations between terminals; now, in one instance, as many as eleven relay stations are interposed. On this particular circuit this number of relay stations fulfils the traffic requirements, but it has been proved that this is by no means the limit. Signals have, in fact, been passed satisfactorily from London to Penang (Straits Settlements) and back through twenty-one relay sets.

Loaded cables were also introduced during Mr. Schaefer's term of office. These introduced several new problems for solution and new methods of working had to be developed. Another introduction was the use of thermionic valves to serve the purpose of magnifying cable signals, resulting in higher speeds with increased stability.

Keenly interested in all branches of Electrical Engineering, Mr. Schaefer made many friends in the profession. To those who worked with him he was always cheerful, encouraging, and beloved by all.

Sir John Denison-Pender, Chairman of the Eastern and Associated Cable Companies, died at his home at Eaton Place, S.W., on the 6th ult. He was seventy-three years of age.

Sir John was brought up in the cable business, for his father, Sir John Pender, was one of the pioneers of the earliest submarine cables and founded the Eastern Telegraph Company. He was created a K.C.M.G. in 1901 and G.B.E. in 1920.

He was buried at Slaugham, Sussex, on Saturday, the 9th March, and a one-minute stoppage of circuits throughout the world-wide system of the Companies took place at 12.15 p.m. to allow the staff on duty to stand in silence in honour of the dead baronet.

The following notice is taken from the *Electrical Review* of the 4th January:—The death of Mr. John Lee, C.B.E., M.A., etc., occurred suddenly on December 24th while on board the "Laconia" on his return journey from New York, where he had been on a visit connected with the business of the Automatic Telephone Co., of which he became a director when he retired last year from the post of Controller of the Central Telegraph Office. Mr. Lee was born in 1867, and as a boy he entered the Post Office service at Liverpool, subsequently rising from the position of telegraphist to assistant superintendent, assistant traffic manager for telephones (1907) and in 1916 being promoted to the post of Inspector of Telegraph and Telephone Traffic. Three years later, after a brief period as Postmaster at Belfast, he came back to London as Controller of the Central Telegraph Office. He had a very full, varied and efficient life in the service. A mere list of the matters in which he was called to figure more or less prominently emphasises the valuable work which an enthusiastic and able man can render during 40 to 45 years. His record comprises the reorganisation of the Indian Railway Telegraph system, membership of the Committee on High Speed Telegraphy, and membership of various delegations to the U.S.A. and to the Continent, including the International Telegraph Conference in Paris over which he presided. He wrote a number of books on telegraph and telephone practice and other subjects, was interested in the principles of scientific management, was profoundly concerned with religious questions and modern movements connected therewith, attended many industrial conferences, was a most acceptable speaker and lecturer and a writer for the Press, while administrative and organising ability and a striking personality also form parts of the outline record of the interests and achievements of one who, according to those who knew him best, was a remarkable man, whose ceaseless industry unfortunately permanently impaired his health, so that he has passed away as a result of a heart attack at the age of 61 years. A Memorial Service was held at Christ Church, Newgate Street.

We regret to record the death on the 21st February of Mr. Edward Raymond Barker, M.I.E.E. He had been ill for many years. Mr. Raymond Barker was born in 1857 and entered the London School of Submarine Telegraphy in 1875. He received appointments later with the Eastern and Brazilian Submarine Telegraph Companies. He became first Assistant Chief Electrician at the submarine cable works of the I.R., G.P. and Telegraph Works in 1891 and remained with that company until he retired in 1912. He saw service in many submarine cable-laying expeditions, invented a calculator board for cable ships and the multitone transmitter, wrote many articles in the *Electrical Review* and published various books and pamphlets regarding the apparatus and methods so closely related to his submarine cable career.—*El. Review, 1-3-29.*

We have received from Mr. Weaver a copy of the Annual Reports for the year ended 31st December prepared for the Advisory Committees for Birmingham District and for Chester, North Wales and Hanley Districts.

HEADQUARTER'S NOTES.

EXCHANGE DEVELOPMENTS.

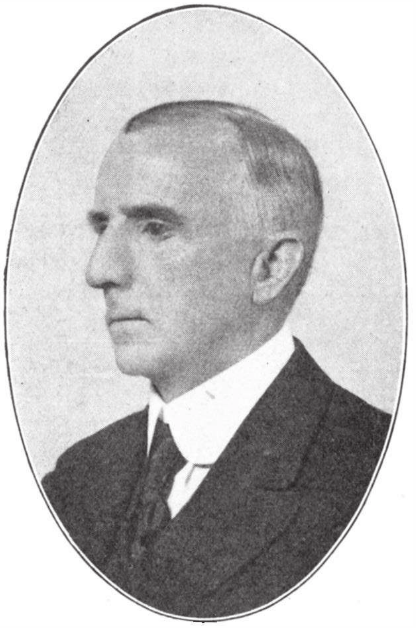
The following works have been completed:—

Exchange.	Type.	No. of Lines.
Ainsdale	New Auto.	618
Bath	,,	3040
Batheaston	,,	130
Cowley	,,	200
Dringhouses	,,	180
Headington	,,	200
Hipperholme	,,	350
Leicester	,,	8600
Sloane	,,	8000
Sowerby Bridge	,,	440
Halifax	Auto Extn.	Junction Equipt.
Cobham	New Manual	600
Connahs Quay	,,	440
Hornchurch	,,	880
Molesey	,,	2280
Petersfield	,,	500
Sutton	,,	4880
Valentine Relief	,,	1500
Anfield	Manual Ext.	1140
Brixton	,,	800
Ryde	,,	240
Speedwell	,,	2480
Winchester	,,	400
Bristol Tramways	P.A.B.X.	210
Clark Chapman & Hall	,,	30
Davis Theatre	,,	30
Dudley Board of Guardians	,,	30
Dunlop Rubber Company	,,	10
Edwards Ringer & Brigg	,,	30
Garner & Son	,,	30
Lloyds Packing Co., Ltd.	,,	30
Manchester Corporation	,,	20
Newcastle-on-Tyne Corpn.	,,	Junction Equipt.
Preston Corporation	,,	30
Rochdale Co-op.	,,	30
Southern Oil	,,	20
Wiggins Teape	,,	30

Orders have been placed for the following works:—

Exchange.	Type.	No. of Lines.
Aldridye	New Auto	135
Aylesford	,,	180
Barming	,,	100
Benton	,,	665
Bearstead	,,	280
Birmingham: Victoria	,,	2815
Birmingham: Harborne	,,	1290
Birmingham: Midland	,,	Positions
Birmingham: Northern	,,	5280
Boughton Monchelsea	,,	200
Davidson's Mains	,,	615
East Newcastle	,,	1520
Fairfield	,,	2700
Felling	,,	285
Gateshead	,,	1900
Gosforth	,,	1615
Hunton	,,	100
Jarrow	,,	570
Kenton	,,	105
Low Fell	,,	950
Maidstone	,,	2100
Newcastle-on-Tyne	,,	9200
Otham	,,	100
Wallsend	,,	800
Wateringbury	,,	200
West Newcastle	,,	1520
Whickham	,,	190
Burslem	Auto Extn.	250
Edinburgh Central	,,	1460
Edinburgh Morningside	,,	870
Edinburgh Murrayfield	,,	650
Edinburgh Newington	,,	660
Longton	,,	95
Newcastle-under-Lyne	,,	160
Park Mechanical Order Wire	,,	—
Swansea	,,	1000
Stockport	,,	360
Stoke	,,	110
Western Mechanical Order Wire	,,	—
Bexhill	New Manual	1460
Bourne End	,,	880
Egham	,,	780
Farnborough (Hants.)	,,	1020
Hazel Grove	,,	900
Herne Bay	,,	1240
Hitchin	,,	570
Sydenham	Manual Ext.	2040
Cheshire Joint Sanatorium	P.A.B.X.	20
Clarke Chapman & Hall	,,	30
Newcastle-on-Tyne Cprn.	,,	Modfn.
Rochdale Co-op.	,,	30
Shell Mex (Southampton)	,,	30
Society L'Ouest Africa	,,	20
Uxbridge Guardians	,,	20

WILLIAM MASTERMAN FRANCE, M.I.E.E.



W. M. France, M.I.E.E.

Mr. France retired on the 31st October after 45 strenuous years in the Telephone Service.

He entered the business in the electrical department of the Lancashire and Cheshire Telephone Coy. in Liverpool in March, 1883. In 1889 he was placed in charge of erection and maintenance of exchange equipment in the Liverpool District, and on reorganisation following the amalgamation with the N.T. Co. in 1893 he was appointed Chief Electrician of the same district. In the following year he was transferred to the E.-in-C's Staff, but with headquarters at Liverpool, and for five years he was engaged in cable apparatus and materials testing at contractors' works and dealing with any special difficulty in connection with cables *in situ*.

Up to this time the manufacture of switchboard equipment in this country was carried out on a very small scale, and great credit is due to Mr. France for the advice and assistance he rendered to both the Company and the manufacturers in the initial stages of this class of work.

In 1899 he came to London and supervised the erection of the more important exchange equipments throughout the country.

In 1903 the Equipment Section was formed at H.Q. and Mr. France was placed in charge. During these early days his work was of great importance to the Telephone Co. and was done with conspicuous success. He remained in this position until 1915, when he was transferred to the Local Lines Section. In 1917 he was appointed S.E., N. Midland District, and in 1919 he returned to London to take charge of the Telephone Section.

In 1921 he was transferred to the Lines Section, where he remained in charge till his retirement.

In connection with the transfer of the National Telephone Co.'s undertaking to the Post Office he rendered most valuable service, more particularly in respect of the valuation of exchange equipments and internal plant. He attended all the sittings at the Law Courts during the Arbitration proceedings, his services being retained by the Company until the completion.

He was Chairman of the I.P.O.E.E. during the session 1926/7.

During his 45 years' service he has had only two days' sick leave and that in the very early days. The short absence was due to continuous work of two days and three nights restoring service at Liverpool Central Exchange after a fire.

He is a prominent Freemason and takes special interest in the Telephone Lodge, of which he was a founder in 1908 and Hon. Treasurer since 1920.

Of the man himself: he has a personality which has endeared him to all who have had the privilege to be associated with him. His prevailing characteristics are thoroughness and modesty; whatever he undertook was well done and his conclusions were sound and well balanced. At the same time he was always anxious to give the credit to those working under his direction rather than to assume it for himself and would make herculean efforts to assist those who required help. He has never allowed his true self to be buried in the hard crust of officialism—a real humanitarian and such a gentleman!

MR. ARTHUR CROTCH.

ARTHUR CROTCH.

On the 31st December last, Mr. Arthur Crotch retired from official duty, having completed 45 years' service. Born and educated at the old cathedral city of Norwich, he entered the telegraphs there in 1883, and later was one of the early workers in the technical movement which brought about so great a change in the character of the telegraph staff of the Kingdom. He joined the engineering side in 1896, commencing at East Dean Repeater Station, was transferred thence to Lowestoft and to headquarters clerical establishment in 1900. Since that time he has been responsible for many works on technical subjects, the best-known, perhaps, being his first venture, " Elementary Telegraphy and Telephony." This was followed by his " Telegraphic Systems " and others, the latest being his " Automatic Telephony." These have been justly praised for their simplicity of treatment and clarity of expression.

For many years he was responsible for the exhibition of patterns and drawings in connection with the placing of orders for telegraph and telephone apparatus. This necessarily brought him into touch with the electrical manufacturing world, and his alert figure and never-failing courtesy will be greatly missed by the representatives of the firms with whom he was for so many years in daily contact.

Mr. Crotch was a man of many parts and always had a multitude of irons in the fire. Organ building (and an organist to boot), Egyptology, Biblical research, architecture, matters ecclesiastical and historical, and above all, literary humorists were his delight and the great love of his life was Charles Dickens, in whose writings he was fairly steeped. Very rare was the occasions which he could not cap with a suitable Dickens' story ! He was also a great London-lover, and is on the lecturing staff of the L.C.C. for London history.

At a large gathering in the Designs Section he was the recipient of a suitable presentation subscribed by his many friends. In the absence of Colonel Purves, Mr. J. R. Gall presided and made feeling reference to Mr. Crotch's qualities. Many other speakers testified to his inveterate love of story-telling and his other humorous qualities. In retirement he will have the opportunity to " go-in " thoroughly for many subjects very near his heart, which have been previously kept out by lack of time. We wish the genial, happy Arthur many years of health and happiness to enjoy the fruits of his labours.

FREDERICK WILLIAM FRANCIS.

Mr. Francis, who retired on the 30th November, started business in 1884 in the office of the Telegraph Superintendent of the L.B. and S.C. Railway, and in the same year he entered as an evening student at Finsbury Technical College, taking the full electrical engineering course under Profs. Ayrton and Perry and then under Prof. Sylvanus Thompson.

Three years later he joined the United Telephone Coy. and was appointed to the experimental and testing branch, then under the control of the late Mr. I. W. Ullett, which maintained the London junction wires, tested cables, wire and apparatus in addition to experimental work. When the various companies amalgamated in 1890, the testing branch was shut down for a time, and after a short period in the office Mr. Francis was transferred to Exchange maintenance work. Single-handed for several years he kept in order all the six London City exchanges, except Avenue.

In 1894 he was appointed one of two Cable Inspectors, the other being Mr. W. M. France, who took over the northern half of the country. Their duties were to test all cables, principally the new paper core cable, at contractors' works and when laid. The inspectors were under the control of the Test Department, with Mr. J. R. Gall in command, but with only one other assistant. From this small beginning the Test Department grew with the increase in the Company's business until it performed the functions, or part of the functions, now administered by several Sections in the P.O., viz., Test, Designs, Construction, Power, and Office of Works.

At the transfer Mr. Francis was appointed Asst. Staff Engineer in the Designs Section, then under Mr. Purves, but later under his old chief, Mr. Gall, with whom he has served as principal assistant for nearly 30 years.

Mr. Francis is a delightful conversationalist, full of quiet humour and with a wonderful gift for mimicry. A more even-tempered man no one could wish to know. Widely read, there is no subject, either scientific or social, upon which he could converse without profit to the listener. He has learned how to assimilate those intellectual foods which ensure peace and happiness within and at the same time form an effectual bulwark against strife without. A real good fellow, modest almost to a fault, his cheerful countenance has always been a tonic to his colleagues.

RETIREMENTS.

In our quarterly return of Staff Changes several well-known names appear under the above heading, amongst them being those of Mr. R. McIlroy, I.S.O., Superintending Engineer of the London District, who bade his colleagues an official farewell on the afternoon of the 27th March; Mr. E. J. Ivison, the head of the Telephone Section at Headquarters; Mr. J. Richardson, Assistant Superintending Engineer, South Eastern District; Mr. W. H. Powning, of Swansea, a stalwart of the early days of the Society of Post Office Engineers and of the I.P.O.E.E., and Mr. W. J. Gwilliam, of the Test Section, Studd Street.

As time goes on, retirements of higher officials have become increasingly frequent and while the process opens vistas of promotion for the younger men one cannot fail to sense a feeling of regret as the veterans who were present practically at the founding of the Department lay down their harness and depart. They set a high standard of duty, these men; it is for the younger men who take up their jobs to maintain that standard.

DEATH OF MR. E. J. WHIBLEY.

We regret to record the death of Mr. Edward James Whibley, which occurred at Boscombe on 13th February. He retired some six years ago, owing to ill-health, and by his absence for this period from the scene of active life, he has faded from the remembrance of many. But to a large number of his old friends still in the service, the news will come with regret.

His record is briefly given below. He entered the C.T.O. as a telegraphist in 1884 and in 1891 he was transferred to the Engineering Branch and took up duty at Cambridge, in the office of the Superintending Engineer (then Mr. Jenkin). In 1899 he was appointed to the Engineer-in-Chief's Office, where he graduated successively as third, second and first class clerk, retiring as we have said, in 1922.

My acquaintance and friendship with our friend began in 1900. Generally bubbling over with high spirits, he infected us all with his great good-nature. He was responsible for all apparatus received and sent out from headquarters, and he had the nose of a ferret for articles borrowed, mislaid or lost. Circulars sent round " as to " the whereabouts of a piece of apparatus produced the usual result, " could not be traced," etc. Then Whibley began his " researches " ; and the chagrin of the man in whose possession it was found—at the back of a cupboard, forgotten—can only be imagined by those who have been the unwitting detainers of loans ! Sometimes, his keenness and his " D Notes " gave occasion for strong language ; but everyone agreed that, if he were a nuisance, he was a very necessary one ! And, the search ended and the object found, the matter was finished with. Whibley had " got " it, and there was an end to it !

Of his happy good nature, one could give many instances. He would lend you £1 to £10 for the asking. And we often wondered at the amount of cash he carried about. But if you used a cheque of his, he would religiously demand the 2d. ! He loved a joke : that it was against himself mattered not. As a teller of tales he was a failure ; indeed, it was borne in on him so often that he found a unique way of amusing us. He would ask, " Did I tell you the tale of the two painters ? " and on getting the negative, he would start on some rigmarole, knowing that we would stop him (forcibly if necessary) and not allow him to proceed. And he loved this as much as if he were a born raconteur ! But I think the great characteristic of the man was his unfailing good temper. However busy, however worried, he would turn for a moment with that boyish laugh of his.

He lost his only son in the war, and he now leaves his wife and two daughters. To them, so bereaved, we offer our heartfelt sympathy. We laid him to rest in Mitcham Cemetery on a day such as he loved, a day flooded with the February sunshine and in harmony with his happy nature.

A.C.

LONDON DISTRICT NOTES.

Telephones.—The following figures show the changes in the number of exchange lines, extensions and stations during the three months ending and the totals at 31st December, 1928:—

	Increase.	Total.
Exchange Lines ...	7,895	355,493
Extensions ...	9,183	301,353
Stations	14,747	598,314

External Plant.—During the same period the changes shown below have occurred in mileage:

Telegraphs.—A nett decrease in open wire of 1 mile and a nett increase of 206 miles in underground.

Telephones (Exchange).—A nett increase in open wire of 50 miles and a nett increase of 88,205 in underground.

Telephones (Trunk).—A nett decrease in open wire of 68 miles and a nett increase of 3,981 in underground.

Pole Line.—A nett increase of 9 miles, the total to date being 5,896 miles.

Pipe Line.—A nett increase of 219 miles, the total to date being 10,260.

The total single wire mileages at the end of period under review were:—

Telegraphs	25,985
Telephones (Exchange) ...	2,456,562
Telephones (Trunk) ...	78,100
Spares	112,331

TELEPHONE EXCHANGE PROGRESS.

During the month of January the following new Manual Exchanges were opened, viz.:—Molesey, Hornchurch and Sutton. These Exchanges, which are of the C.B. No. 1 type, were equipped with an initial capacity of 2,280, 880 and 4,880 lines respectively.

Other new Manual Exchanges recently completed are:—Pollards, with an equipment for 1,800 lines, which was opened on February 27th, and Valentine, with an equipment for 1,500 lines, which was opened on February 28th.

The following additions to plant are in hand by the Department's staff:—

Exchange.	No. of Lines.
Malden	1,560
Wimbledon	1,080
Hounslow	1,780

The General Electric Company is carrying out an extension of 1,200 lines at the Greenwich Exchange, which it is anticipated will be completed early in May.

New Manual Exchanges are in the course of erection at Thames Ditton (Emberbrook) and at Upminster; both Exchanges are being installed by the Standard Telephone and Cable Co., Ltd.

AUTOMATIC EXCHANGES.

Further progress has been made in the conversion to automatic working by the opening on January 5th of the new Western Exchange (7,100 lines), on March 2nd of Temple Bar (7,700 lines), and on March 9th of Archway (3,100 lines).

Installation work is in hand at the following Automatic Exchanges:—

Exchange	No. of Lines	Exchange	No. of Lines
Shepherds Bush	4000	Edgware	1300
Primrose Hill	6900	Hendon	3100
Beckenham	3000	Flaxman	9900
Reliance	2700	Fulham	7500
Metropolitan	9500	Mitcham	1480
National	9500	Hillside	2350
Maida Vale	7500	Ilford	3000

SITES.

The purchase of sites for the undermentioned Telephone Exchanges has been completed during the past three months:—

Ewell (Manual).
Stamford Hill (Auto.)
Surbiton (Manual).

AREA CORRECTION TRANSFERS.

17,134 Area Correction Transfers were carried out in conjunction with the March issue of the London Telephone Directory.

TELEGRAPHS.

Teleprinters.—Testing sets have now been provided which will enable instruments to be tried by working through to each other on an artificial line. The arrangement provides for testing Teleprinters Nos. 1-A, 2-A and 3-A.

The experimental working at Knightsbridge with alternating motors on No. 3-A machines still continues. It has been found desirable to fit signalling apparatus, consisting of generator and bell, to several Teleprinter circuits, and thus obviate the necessity for continuous running of the motor.

Three sets of the Siemens Halske type of apparatus have been installed for working to Norway. There are now five sets working at the C.T.O.

TUBES.

Power-worked tubes are now being fitted between the Counter and Instrument and Delivery rooms in important Branch Telegraph Offices.

Fans with press-button starters fixed adjacent to the Terminals are being successfully used, and are found to be a great improvement on the old hand-pump system.

The C.T.O. House-tubes are being converted to single-way working. Hitherto power has been supplied at one end to two or three tubes placed in series, with the result that if a block occurs in one Section, all three Sections are liable to be stopped. The new system should effect a considerable improvement, as the transit time will be much reduced and the working be of a very simple character.

The very cold weather in February caused trouble on some of the street-tubes. Moisture which condensed in the pressure tubes, accumulated and froze, thus causing a stoppage. Considerable difficulty was experienced in clearing away the ice which blocked the passage of the carriers.

TELEPHONE CABINETS.

A suite of Cabinets in which the folding doors are of teak and the bodies of hardwood, has been made at Cornwallis Road and erected at Mansion House Station. This follows the precedent set at Goodge Street, Bond Street, Charing Cross, etc. A pair made of old bodies with oak exteriors has been erected in Kensington High Street Arcade, and has evoked appreciative remarks.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

LOCAL CENTRE NOTES.

LONDON CENTRE.

The third meeting of the Session was held on December 11th, when Mr. A. J. Gill, B.Sc., M.I.E.E., gave a lecture " Radio Communication on Short Wave-lengths." The lecture was illustrated and at the close Mr. Gill gave a demonstration of the directional properties of a short wave aerial.

On Jan. 8th Mr. R. W. Palmer, A.M.I.E.E., gave a lecture, " The Measurement of Relay Times." The paper dealt comprehensively with the many types of apparatus which have been developed and was illustrated by lantern slides and demonstration apparatus.

On Feb. 12th Mr. A. J. Aldridge, A.C.G.I., A.M.I.E.E., gave a lecture on " The Measurement of Sound and its Application to Telephony." The lecture was illustrated and a good discussion ensued.

On March 12th, Mr. W. G. Radley, B.Sc. (Hons.), A.M.I.E.E., gave a lecture, " X-rays and the Structure of some Engineering Materials." The lecture was illustrated and the attention of the audience and the interesting discussion showed that keen interest had been aroused.

INFORMAL MEETINGS.

The third Informal Meeting was held on January 22nd, when Mr. H. E. Morrish, A.M.I.E.E., opened a discussion on " Jointing and Testing of Cables." The discussion aroused the keenest interest and Mr. Morrish ably replied to the many questions raised.

At the meeting on February 26th, Mr. W. Dolton, M.I.E.E., opened a discussion on " Inspection of Wireless Stations in the London Engineering District." In the course of an instructive discussion Col. Angwin and Mr. Matthews, of the Radio Section of the Engineer-in-Chief's Office, paid a tribute to the work of the Inspecting Officers.

Visits.

Successful visits have been made to the Repair Depot of the London General Omnibus Co., Ltd., at Chiswick. The extent of the Works made one realise how much skill and organisation is devoted to the Bus Services, whilst the courtesy and hospitality shown were much appreciated.

Visits to the Barking Generating Station have also been made. This Generating Station, owned by the County of London Electric Coy., Ltd., is said to be the largest in the Country. The size and efficiency of the Steam Plant; the apparent absence of switches in the switch room; the fire extinguishing plant, and the intricacies of the control room, made the visit interesting and instructive. T.H.

NORTHERN CENTRE.

Mr. Thos. Davidson read a paper on " Underground Breakdown Organisation " before a well-attended meeting on the 21st December.

The subject was dealt with under the following headings:—

(1) The method of advising faults.
(2) The provision of testing apparatus.
(3) The recording of alternative routes to each main cable, to provide speakers and testing wires for localising complete breakdowns, and to afford provision for crossing over important circuits in the faulty cable.
(4) Provision of emergency tool kits and materials necessary for the temporary repair of faults to be stored at some point easy of access.
(5) Method of obtaining staff to deal with the breakdown.
(6) Provision of the necessary transport for staff and materials.

In his paper, Mr. Davidson suggested, among other things, that:

(*a*) A cable testing officer should be allocated to each Engineering Section, to be responsible for the localising of all main cable faults in the section.

(*b*) A service telephone should be installed at the residence of the testing officer for use in the event of faults occurring outside normal hours of duty. Each testing officer should be supplied with a Bridge Megger, which should be in his personal custody. Copies of the alternative routes to main cables should be supplied to each Test Room.

(*c*) An Emergency Tool Kit (the composition of which was given in an appendix to the paper) should be held at the Section Headquarters, where it would be readily accessible at all times, all breakdown apparatus and tools being painted red or other distinctive colour in order to be easily recognisible. The provision of emergency rations, where necessary, for men when engaged on breakdown work.

(*d*) The use of a $1\frac{1}{2}''$ semi-rotary pump on stand was advocated in place of the floodgate pump generally used on ground of portability.

(*e*) The earmarking of a ton van for breakdown work in each section, the van being employed on short journey work when not in use on breakdowns. The provision of motor cycle combinations for the use of testing officers was also suggested.

The paper concluded with a detailed description of the methods adopted in dealing with faults and returns to be made, the forms to be used, and the steps to be taken in special cases (*e.g.*, Electrolysis).

SCOTLAND WEST CENTRE.

Following is a cutting from the " Glasgow Herald," of the 4th February, dealing with a lecture held under the auspices of the Scientific Society of the Royal Technical College, Glasgow, to which members of the Scotland West Local Centre were invited. Many members of the Local Centre availed themselves of the invitation to be present:—

" PICTURES BY WIRELESS.

" POSSIBLE EFFECT ON NEWS TRANSMISSION.

" The ' Glasgow Herald ' System.

" The various systems of picture telegraphy which are now in use in newspaper offices and elsewhere were described in full technical detail by Mr. E. S. Ritter, the London G.P.O. specialist in this form of transmission, at a meeting of the Scientific Society of the Royal Technical College, Glasgow, on Saturday night. The meeting was held in the College, and Professor Mellanby, president, was in the chair.

" G.P.O. Specialist Explains.

" Mr. Ritter defined picture telegraphy as the transmission of print, drawings, and sketches in black, white, or facsimile, and also the transmission of photographs, half-tones, etc., either over a telephone line or by radio circuits, or by a combination of the two. With the aid of photographs—originals, transmitted, and reproduced in newspapers—and of specimen parts of the transmitting and receiving systems, in addition to a number of lantern views and diagrams, he gave a full explanation of the working of the Siemens, Bell, Belin, Bart Lane, Marconi facsimile, and the Fultograph systems.

" At the close of the lecture a short discussion took place, in the course of which Mr. Ritter elaborated some of his remarks regarding various parts in the instruments.

" Future of Picture Telegraphy.

" On the invitation of the chairman, Mr. A. M'L. Ewing, manager of Messrs. George Outram and Co., Ltd., referred to the success that has attended the operation of the Siemens system of picture telegraphy since it was installed some time ago at the Glasgow and London offices of ' The Glasgow Herald ' and its associated newspapers. Since it had been installed, he said, very little trouble had been experienced in its working. He believed there were even greater possibilities in this form of transmission than had yet been attained—that the day might come when they might not only have pictures transmitted but also a very much speedier transmission of news. At present, with two telegraph lines in use, a speed of about 300 words a minute was attained. He understood that developments which were now under consideration by the Post Office would increase that capacity very greatly and possibly provide for the transmission of pictures at the same time, or at any rate, over the same wire. One estimate placed the output at very much higher than the 300 words a minute obtained just now. If they got news transmitted with as great accuracy and regularity as they got pictures at the present time he did not think they would have anything to complain about.

" Reproduction the Better Picture?

" Alluding to two views of the King which had been shown on the screen, and which had been sent by means of ' The Glasgow Herald ' apparatus, Mr. Ewing remarked that he had asked the London staff to transmit the picture and to send on the original of it. A slide had been prepared of the two, and the reproduction had been so fine that he thought there would be some difficulty in distinguishing the one from the other. On the screen it appeared to him that the transmitted picture was really the better of the two. (Laughter.) Possibly, however, that was because of the character of the paper on which it was printed.

" Mr. Percy Morris, ' The Scotsman,' spoke of the working of the Belin system, which has been installed in the offices of that newspaper, and indicated that some slight improvement might be effected in the matter of synchronisation and in the size of the picture. He was confident, however, that Belin had the right idea in regard to reception.

" A vote of thanks to Mr. Ritter was moved by the Chairman, and Mr. Ewing, in seconding, expressed appreciation of the co-operation and assistance that the Post Office had given in this new form of transmission of pictures to newspapers."

The third meeting of the current session was held on 4th February, when the lecturer was Mr. F. G. C. Baldwin, M.I.E.E., Assistant Superintending Engineer of the Northern District, and the subject " Scientific Organisation and the Post Office Engineering Department."

The paper having already been printed and issued to the members, the lecturer confined himself to certain portions of the paper and some considerations which arose since the paper was printed. With the aid of lantern slides the ground was covered in an instructive and interesting fashion and a good discussion ensued.

Under the auspices of the Scottish Centre of the Institution of Electrical Engineers a meeting was held in the Royal Technical College on

Tuesday, 12th February, when a paper by Mr. W. B. Woodhouse on "Overhead Electric Lines" was presented by Major H. Carter. Members of the I.P.O.E.E. were specially invited and there was a good response. The paper dealt specially with strength tests, carried out by the British Electrical and Allied Industries Research Association in regard to single "A," and "H" poles used in connection with overhead power lines. The methods of making the tests was illustrated by means of a cinematograph film and lantern slides.

On conclusion of the paper a discussion took place which was taken part in by several representatives of the Department.

H.C.M.

NORTH WESTERN CENTRE.

A meeting of the Centre was held in St. George's Hall, Preston, on the 15th January, 1929, when a lantern lecture entitled "The Early Development of Telephone Switching" was delivered by Capt. F. G. C. Baldwin, M.I.E.E.

The Chairman (Mr. J. M. Shackleton, M.I.E.E.) presided.

Capt. Baldwin, after his opening remarks, described the earliest telegraph switching appliances and the origin of the telephone exchange and proceeded with a description of the first telephone exchange in 1879. He then traced the evolution of the various switching devices up to the present day explaining the salient points of each system in passing. The lecture was illustrated by upwards of 50 interesting lantern slides.

On the 4th March, 1929, Mr. C. Coward contributed a paper entitled "Unit Construction and Maintenance Costs (External) from Fundamentals."

The subject was approached from the point of view of the actual work rather than from the final statistics and the paper was broadly divided into two sections, viz.:—Maintenance and Construction. Mr. Coward traced the system from its inception to the form in which it is now known and dealt at length with various aspects of the subject, relating actual experiences and suggesting improvements. The paper was followed by a discussion and in view of the interest aroused by the lecture and the paramount importance of the subject at the present time it was decided to postpone the proceedings and arrange a further meeting to continue the discussion.

D.B.

NORTH WALES CENTRE.

The Session was opened on 10th October, 1928, when Captain J. Coxon, M.I.E.E., read a paper entitled "Secondary Batteries." This paper had been specially asked for by the local Committee and was designed to assist members in charge of this class of plant. After a brief reference to the earlier types of secondary cell, Captain Coxon devoted himself to the types used in this Department, their installation and layout, their methods and rates of charging. In addition to a fine collection of slides there were many exhibits including specimen cells and plates of acid and also of nickel-iron-alkali cells. The paper was followed by a discussion.

The second meeting was held on 14th November, 1928, when Mr. A. S. Renshaw (E.-in-C.O.) contributed a paper entitled "Some considerations relating to the Clerical Organisation of the Engineering Department." Mr. Renshaw commenced at the year 1912 by describing the conditions existing at the time of the telephone transfer, which gave rise to the appointment of the Walkley Committee (1914) and he outlined the methods of investigation adopted by that Committee and the results which were achieved. The ratio of clerical staff to workmen was shown to have been considerably reduced in subsequent years, and at the same time the delay in furnishing the various monthly accounts had been greatly reduced. Mr. Renshaw then referred to standardisation, co-ordination and inspection, to the policy of devolution, recruitment, training and future developments, and he had in the subsequent discussion a long list of eager enquiries to meet.

The third meeting was held at the Central Cinema on 11th December, 1928, when the programme was of an unusual character, consisting entirely of technical films. There was an attendance of over 200, including visitors from the Surveyor's and Head Post Offices, Shrewsbury Technical College, Shrewsbury Secondary Schools and the Shropshire Philosophical Society. The programme commenced with the film " Voices across the Sea," followed by six other films lent by the Standard Telephones & Cables Ltd. illustrating telephones and cables, manufacture and development, broadcasting and receiving, valve repeaters, telephone transmission and switching, and the operation of the thermionic valve. The projection of the films was followed with great interest and this variant from the usual programme was voted a success.

The fourth meeting was held at Fordrough Lane Stores Depot, Birmingham, on 10th January, 1929, and prior to the meeting members were conducted in parties over the Stores Depot, Factory and Testing Branch, officers of the various staffs acting as guides, and explaining the different operations carried out. At the meeting Captain Cave-Brown-Cave, B.Sc., read a paper on " Modern Views on the Structure of Matter," in which he mentioned one by one the famous figures in the scientific world during the past 300 years, side by side with their most important discoveries, thus showing the steps by which scientific knowledge has advanced to its present position, which was fully outlined. Finally in dealing with present day knowledge Captain Cave-Brown-Cave gave a short talk on " Relativity " and described some of the methods by which scientific experiments are brought to proof. After an interesting discussion and votes of thanks to the lecturer and to the Controller, Stores Department, for his kindness in allowing the visit, the members inspected a collection of microscope slides illustrating experiments carried out by Captain Cave-Brown-Cave, Mr. W. J. Eves and Mr. P. C. Martin.

The fifth meeting was held at Shrewsbury on 6th February, 1929, when Mr. E. J. Jarrett read a paper entitled " Director Working." At the outset Mr. Jarrett exhibited a number of slides showing early switchboards of the flat magneto type and the various improvements leading to the present day C.B. switchboard, and indicated the devices by means of which in each successive stage, the time of operating was reduced, until, eventually the operators cord circuit was cut out altogether in the automatic exchange. The various operations in automatic apparatus and the designing of auto exchanges were then touched upon and the conversion of the Birmingham Exchange and the lay-out of plant in that area were outlined. In conclusion, the Tandem Exchange and Coder Call Indicator Exchange were described, and Director Working fully explained.

The sixth meeting was held on 27th February, 1928, and the members heard Mr. E. J. Woods, A.M.I.E.E. (E.-in-C.O.), read his paper on " The Main Underground Trunk Cable System of the British Isles." The paper has already been summarised in connection with Mr. Woods' visits to other Districts, and its reading on this occasion was followed by a long and interesting discussion.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

Officers of Colonial and Foreign Telegraph Administrations who are engaged in Electrical Engineering Works may be admitted as Colonial and Foreign Corresponding Members respectively, after application.

Subscription payable annually in advance on 1st April in each year :

Colonial Members	...	...	£1 0 0
Foreign ,,	...	...	£1 10 0

These sums include Annual Subscription to the Journal of P.O. Electrical Engineers and the supply of all Professional Papers issued during the period covered by subscription.

Forms of application for Colonial and Foreign Membership can be obtained on application to

The Secretary,
Institution of P.O.E. Engineers,
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Colombo,
Ceylon.

A. J. Kellaway, Esq.,
Department of Posts and Telegraphs,
P.O. Box 366,
Pietermaritzburg,
South Africa.

CAPTAIN J. P. PRICE.

CAPTAIN J. P. PRICE.

CAPTAIN J. P. PRICE attained his official majority in January last with 45 years' P.O. service to his credit. This record began in December, 1883, at Chester as a Telegraph Learner and in his earlier years of service he shared with others the unique experience of telegraphing the speeches of the late Rt. Hon. W. E. Gladstone in the North Wales Area as a member of the Special Service Staff set up for the purpose.

In 1896 he was appointed a Telephone Instructor for the taking over of the Telephone Trunk Service from the late National Telephone Company, visiting 62 towns in the British Isles in connection with this work. He also shared in the trunk transfer arrangements to Post Office control and the opening of many new Trunk Exchanges. At the finish of this work he was appointed to the Engineering Department in the N. Wales District as Sub-Engineer. Whilst in this district he began his well-known interest in paper dry core cables, and was early instrumental in getting the standard of insulation resistance raised above that then accepted for them, and specifications were adjusted to correspond.

He was transferred as a 2nd Class Engineer to the Engineer-in-Chief's Office, London, in 1898, taking up the work of testing and examining cables, wires and apparatus at manufacturers works, thus getting a valuable experience which stood him in good stead later.

In 1900 he joined in the work of telephoning London, and controlled duct and pipe laying, cabling, jointing and exchange equipment works in the Metropolitan (S) District, in an area which embraced the S., SW. and W. postal districts and the Thames Valley districts of Kingston, Putney and Wimbledon.

Following his promotion in 1901 to a 1st Class Engineership, he assumed the chargeship of the Wandsworth Section of London. He was responsible for much important work of a construction and maintenance character in modernising this area, including the provision of many miles of air-space paper-core cables for the service of all the National Telephone Exchanges there. Later he took over the control of the Holborn External Section of the Central London Area and from thence was transferred to the Engineer-in-Chief's Office again.

In March, 1911, he was appointed to the South Eastern District as Assistant Superintending Engineer, a post which he held for nearly 18 years. His former experiences of construction works and maintenance methods proved very valuable assets, for they enabled him to deal efficiently with the many difficulties he was called upon to dispose of, and to the credit of the district.

During the late War he was appointed P.O. Engineering adviser to the 2nd Army Home Defence, the Southern Army and the Kent Independent Force, with the rank of Captain. He was also Brigade Signal Officer to the South London Volunteer Regiment.

He was educated at the Chester Diocesan Training College, where he first became interested in electrical subjects. This interest he kept going throughout his service, keeping himself well informed at all times of the changes and advancement of them, by reading, lectures and classes. This spirit he was always inculcating into the members of the Staff, encouraging them to extend their knowledge in every way open to them. For the I.P.O.E.E. he had a very warm attachment and was never weary in advocating its usefulness.

All this, and much more, was testified to by many of his old colleagues who met at Croydon in December last to bid him " au revoir." The occasion was used by the Superintending Engineer, G. F. Greenham, Esq., in a happily-phrased speech, to present Mr. Price with a gold watch as a token of esteem and regard, subscribed for by his many friends in the district.

Mr. Price has left us in good health and vigour and with faculties as keen as ever, from which it can be deduced he will not " rust " in retirement. On the contrary, he is to take an active interest in motor cruising on an extensive plan, as skipper of the motor launch " Aloha Oe," in which he proposes to visit many of the rivers, creeks and canals of these islands and possibly continental ones as well. This is an excellent way of spending one's retirement and we feel sure he will enjoy it—he deserves to. We sincerely hope he will and cordially wish him " all the best " for a very long time to come.

G.

BOOK REVIEWS.

" Electrical Transmission and Distribution." Edited by R. O. Kapp, B.Sc. Sir Isaac Pitman & Sons. Volumes I. and II. 6/- each.

These are the first two volumes of a series of eight in which it is proposed to treat the problem of electrical transmission and distribution in its entirety. The book is divided into various sections, each written by a specialist on the particular subject dealt with.

Volume I. deals with the construction, erection and maintenance of overhead lines and concludes with a section on distribution in rural areas. The matter is dealt with throughout in a rather popular manner, but the details regarding the construction of overhead lines are set out very clearly and the matter represents a very up-to-date summary of modern practice. The section dealing with " Maintenance " is written largely from the view point of organization of the work. The section dealing with " Distribution in Rural Areas " is written by Mr. Borlase-Matthews. It is not surprising to find that the views on the Overhead Lines Association are very prominent.

Volume II. deals with power cables. It is divided into four sections entitled " Manufacture of Power Cables," " Cable Laying Methods," " Underground Cables " and " Consumers' Connections." The first section gives a very complete outline of manufacturing methods, with many excellent photographs of works and plant of a type not usually shown in technical works. The second section illustrates very clearly the various standard methods in use, together with methods adopted in a number of unusual cases. Many of the illustrations are easily recognisable, as examples of work by the Standard Telephones and Cables, Ltd. The third section deals with testing and maintenance. It contains a brief but very clear exposition of the problems of chemical and electrolytic corrosion.

H.C.

We welcome the arrival of the first number of " Civil Service Arts Magazine," which will be published quarterly, price sixpence. The editor, Mr. S. McKechnie, assisted by a weighty and influential committee, has produced a very good number to begin with, and it is understood there will be no lack of first rate material in the future. In the present issue Drama and Opera, Photography, Art, Music as pursued and practised in the Civil Service are adequately dealt with.

Commissioned agents are wanted for the magazine. Subscriptions sent direct to the Circulation Manager, " Civil Service Arts Magazine," Room 208, Treasury Chambers, Whitehall, S.W.1, should be accompanied by sevenpence in stamps. Yearly subscriptions are invited.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to	Date.
Gomersall, E., O.B.E.	Deputy Suptg. Engineer, London District.	Suptg. Engineer London District.	1-4-29
Cornish, H. V.	Assistant Suptg. Engineer, London District.	Deputy Suptg. Engineer, London District.	1-4-29
Hedley, J.	Assistant Staff Engineer, Telephone Section, E.-in-C.O.	Staff Engineer, Telephone, Section, E.-in-C.O.	1-4-29
Preston, E. L.	Assistant Engineer, Bristol Section, S.W. District.	Executive Engineer, Swansea Section, S. Wales District.	To be fixed later.
Cowburn, W.	Assistant Engineer, Liverpool Int. South Lancs. District.	Executive Engineer, Blackburn Section, N.W. District (vice Mr. R. C. Balcombe, transferred to Taunton, headquarters of a new section).	To be fixed later.
Pratt, A. J.	Assistant Engineer Liverpool External Section, S. Lancs. District.	Executive Engineer, Liverpool External Section, S. Lancs. Dist.	21-12-28
Linch, R.	Chief Inspector, Testing Branch, London.	Assistant Engineer, Testing Branch Birmingham.	13-1-29
Glover, D. W.	Unestablished Skilled Workmen. E.-in-C.O.	Inspector, E.-in-C.O.	15-12-28
Collinette, L. T.	Skilled Workmen, Class I., London Engineering District.	Inspector, London Eng Dist	To be fixed later.
Humphreys, L. H.	,, ,,	,, ,,	
Moore, B. J.	,, ,,	,, ,,	
Robbins, E. H.	,, ,,	,, ,,	
Maggs, C. W.	,, ,,	,, ,,	
Sell, S. F.	,, ,,	,, ,,	
Hutchings, E. J.	,, ,,	,, ,,	
Peel, W.	,, ,,	,, ,,	
Barber, A. W.	,, ,,	,, ,,	
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Thompson, L. M.	,, ,,	,, ,,	
Hall, H. C.	,, ,,	,, ,,	
Phipps, G. R.	,, ,,	,, ,,	
Wheatley, J. J.	,, ,,	,, ,,	
Hutchinson, C. H.	,, ,,	,, ,,	
Sharp, J.	,, ,,	,, ,,	
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Brock, W. P.	,, ,,	,, ,,	
Bydawell, P. J.	,, ,,	,, ,,	
Evans, W. A. A.	,, ,,	,, ,,	
Swan, G. E.	,, ,,	,, ,,	
Sallnow, C. B.	,, ,,	,, ,,	
Barnes, F. L.	,, ,,	,, ,,	
Howard, A. A.	,, ,,	,, ,,	
Maynard, W. F.	,, ,,	,, ,,	
Benham, F. W.	,, ,,	,, ,,	
Wills, H. H.	Skilled Workman, Class II., London Engineering District.		
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Richards, H.	,, ,,	,,	
Pettitt, V. R.	,, ,,	,,	
Bull, W. J.	,, ,,	,, ,,	
Hills, J. A. E.	,, ,,	,,	
Dutton, E. S.	,, ,,	,,	
Hart, S.	,, ,,	,, ,,	
Rolin, F. W.	,, ,,	,, ,	
Doubrowsky, T. L.	,, ,,	,, ,,	
Rumary, F. J.	Skilled Workman, Class I., Radio Branch.	Inspector, Radio Branch.	To be fixed later.
Rhodes, W.	,, ,,	,, ,,	
Bailey, A. J.	,, ,,	,, ,,	
Stewart, T.	,, ,,	,, ,,	
Mitchell, H. T.	,, ,,	,, ,,	
Cooper, W. D.	,, ,,	,, ,,	
Thomsett, H. S.	,, ,,	,, ,,	
Lynes, F. A.	,, ,,	,, ,,	

Appointments.

Name.	From	To	Date.
Millen, G. J.	Probationary Inspector E.-in-C.O.	Inspector, E.-in-C.O.	1-1-29
Perryman, C. F.	Probationary Inspector E.-in-C.O.	,, ,,	
Hibbs, A.	Probationary Inspector, S. Mid. Dist.	Inspector, S. Midland District.	
Chandler, R. W.	Probationary Inspector, Grimsby Radio.	Inspector, Grimsby Radio.	
Salt, R. S.	Probationary Inspector, Eastern Dist.	Inspector, Eastern District.	
Bavin, A. E.	Probationary Inspector, London Engineering District.	Inspector, London Engrg. Dist.	
Seymour, E. H.	Probationary Insp., S. Lancs. Dist.	Inspector, S. Lancs. District.	
Hayes, H. C. S.	Probationary Insp., E.-in-C.O.	Inspector, E.-in-C.O.	
Buck, G. L. N.	Probationary Insp., E.-in-C.O.	,, ,,	
Roberts, J. H.	Probationary Insp., Ldn. Engr. Dist.	Inspector, London Engrg. Dist.	
Coleman, W. L. A....	Probationary Insp., S. West Dist.	Inspector, S. West District.	
Neale, J.	Probationary Insp., E.-in-C.O.	Inspector, E.-in-C.O.	
Styles, G. E.	Probationary Insp., Ldn. Engr. Dist.	Inspector, London Engrg. Dist.	
Knox, A. H. C.	Probationary Insp., E.-in-C.O.	Inspector, E.-in-C.O.	
Lowne, W. R. J.	Probationary Insp., S. East Dist.	Inspector, S. East District.	

Transfers

	Rank.		To	Date.
Tattersall, J. T.	Executive Engineer	N.E. District.	S. West District.	27-1-29
Cresswell, H. G. B.	Assistant Engineer	London Engr. District.	E.-in-C.O.	1-10-28
Garnett, J. A.	,,	Scot. West.	London Engr. Dist.	8-1-29
Govett, C. W.	,,	London Engr. District.	E.-in-C.O.	13-1-29
Hobson, J. W.	,,	Scot. East.	Northern District.	6-2-29
MacDermott, C. N.	,,	E.-in-C.O.	Met. Police Dist.	1-1-29
Marsden, W. H.	Chief Inspector	N.E. District.	S. West District.	1-1-29
Crank, F. G.	Inspector	Devizes Radio.	Portishead Radio.	1-2-29
Turvey, G. H.	,,	N. Midland Dist.	Eastern District.	9-12-28
Coleman, W. L. A.	,,	S. West District.	London Engr. Dist.	10-2-29
Seymour, E. H.	,,	S. Lancs. District.	,,	10-2-29
Sims, A. E.	,,	S. West District.	E.-in-C.O.	20-1-29
Ingram, C. P.	,,	N. Midland Dist.	,,	27-1-29
Gilby, F. W.	,,	N. Midland Dist.	,,	27-1-29
Gambier, J. E.	,,	S. West District.	,,	3-2-29
Anderson, E. W.	,,	S. West District.	,,	3-2-29
Couch, P. R.	,,	S. West District.	,,	3-2-29
Sheriff, L.	,,	N. Wales.	,,	7-2-29
Chapman, R. H.	,,	N. Wales.	,,	10-2-29
Ellis, H. O.	,,	S. West District.	,,	10-2-29
Brock, P. R. W.	,,	London Engr. District.	,,	10-2-29
Missen, H.	,,	London Engr. District.	,,	10-2-29
Markey, J. M.	,,	Northern District.	,,	3-3-29
Longmore, F. W.	,,	Northern District.	,,	3-3-29

Retirements.

Name.	Grade.	Districts.	Date.
McIlroy, R., I.S.O.	Superintending Engineer.	London.	31-3-29
Ivison, E. J.	Staff Engineer.	E.-in-C.O.	31-3-29
Richardson, J.	Assistant Suptg. Engineer.	S. East.	7-3-29
Powning, W. H.	Executive Engineer.	S. Wales.	15-2-29
Gwilliam, W. J.	,, ,,	Testing Branch.	31-3-29
Sirett, C. J.	Assistant Engineer.	S. Midland.	24-3-29
Stewart, J. H.	,, ,,	London.	31-12-28
Tanner, L.	,, ,,	N. East.	31-1-29
Jessup, H. W.	Chief Inspector.	Testing Branch.	18-3-29
Collyer, A. J.	Inspector.	S. Midland.	17-12-28
Parvin, J.	,,	S. Wales.	31-12-28
Berry, A.	,,	S. Wales.	31-12-28
Kitcheman, S.	,,	N. East.	31-12-28
Halmshaw, C. A.	,,	N. East.	5-1-29
Hooper, C. F.	,,	S. East.	28-2-29

DEATHS.

Name.	Grade.	District.	Date.
Barker, A. J.	Chief Inspector.	Testing Branch.	28-1-29
Hill, P. W. R.	,, ,,	S. West.	5-2-29
King, I.	,, ,,	London.	5-2-29
Dowdall, F. F.	Inspector.	London.	15-2-29
Ashworth, J.	,,	S. Lancs.	23-2-29

CLERICAL ESTABLISHMENT.

PROMOTIONS.

Name.	From	To	Date.
Stephenson, W. H.	Acting Staff Officer. E.-in-C.O.	Staff Officer, E.-in-C.O.	3-1-29
Ramsay, J.	,, ,,	,, ,,	31-1-29
Hoggarth, H. J.	First Class Clerk. E.-in-C.O.	Acting Staff Officer. E.-in-C.O.	3-1-29
Davidson, R. S.	Acting Executive. Officer E.-in-C.O.	Executive Officer, E.-in-C.O.	31-1-29
Ost, H. J.	,, ,,	,, ,,	31-1-29
Gordon, F.	,, ,,	,, ,,	31-1-29
Hamilton, C. J.	Clerical Officer E.-in-C.O.	Acting Executive Officer E.-in-C.O.	22-9-28
Emmett, H. H.	Clerical Officer, London District.	Higher Clerical, London District.	13-1-29
Frewin, W. D.	Clerical Officer, London District.	,, ,,	13-1-29
Hamilton, C. J.'	Acting Executive Officer, E.in-C.O.	Executive Officer, E.-in-C.O.	10-2-29
Bate, F.	Clerical Officer, N. Mid. District.	Executive Officer, E.-in-C.O.	10-2-29
Aspden, S. C.	Clerical Officer, E.-in-C.O.	Acting Executive Officer.	10-2-29

RETIREMENTS.

Name.	Grade.	Date.
Simms, J. T.	Higher Clerical Officer (Ireland, N.)	22-2-29
Swansborough, R.	Higher Clerical Officer (London District).	31-3-29
Copp, S.	Higher Clerical Officer (London District).	31-3-29

APPOINTMENTS.

Name.		Date.
Manning, W. J.	To Executive Officer E.-in-C.O. from Open Competition.	14-1-29

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All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, Alder House, London, E.C.1.

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THE
Post Office Electrical Engineers' Journal

THE EQUIPMENT OF THE CENTRAL TELEGRAPH OFFICE, NEW DELHI

N. F. Frome, D.F.C., B.Sc., A.M.I.E.E.

INTRODUCTION.—In a previous number of the Journal a short description of the telephone and telegraph system of New Delhi was published (Vol. 20, Part 3, page 160). The article mentioned briefly the equipment installed in the Central Telegraph Office in the new city. It is thought that a more detailed description of the plant would be of interest.

As was previously noted, the office has been equipped on a remote control basis following American practice, the instrument room fittings being confined only to those units of the apparatus necessary for traffic operations. The remaining apparatus is installed in an adjacent room known as the " Test Room." The many advantages gained by this system are indicated in the course of the description of each unit.

Test Boards and Testing Apparatus.—The telegraph and telephone lines are brought into the test room in underground cables, which are terminated on an ordinary telephone type M.D.F. From the cable terminal tag blocks all lines are jumpered *via* protecting apparatus to the "line" tag blocks of the test boards. The test boards are fitted with ten-line five-point break jack strips, the strips of jacks forming the terminations of the line and apparatus units. Permanent cross connections of the units are made to the inner springs of the jacks through jumper fields.

Trunk Lines.—All trunk lines are arranged to

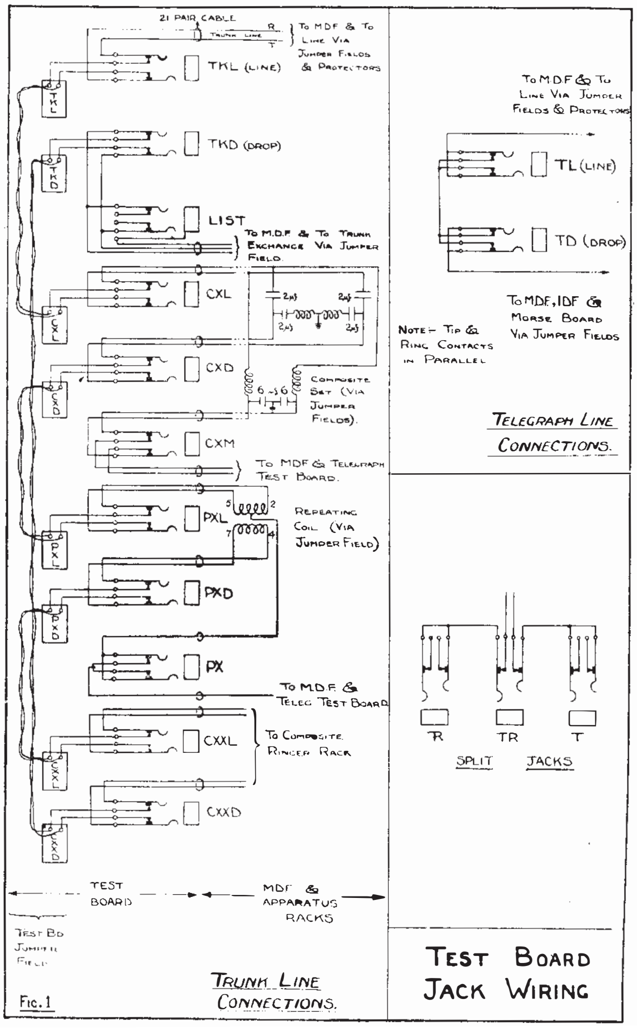

21 PAIR CABLE
R
TRUNK LINE
T
To MDF & To Line Via Jumper Fields & Protectors
TKL (LINE)
TKL
TKD (DROP)
TKD
LIST
To M.D.F & To Trunk Exchange Via Jumper Field.
CXL
2μf
2μf
2μf
2μf
CXD
6 μf 6
Composite Set (Via Jumper Fields).
CXM
To MDF & Telegraph Test Board.
5
2
PXL
7
4
Repeating Coil (Via Jumper Field)
PXD
PX
To M.D.F. & Teleg Test Board
CXXL
To Composite Ringer Rack
CXXD
TEST BOARD
MDF & APPARATUS RACKS
Test Bd Jumper Field
TRUNK LINE CONNECTIONS.
To MDF & To Line Via Jumper Fields & Protectors
TL (LINE)
TD (DROP)
To MDF, IDF & Morse Board Via Jumper Fields
Note— Tip & Ring Contacts in Parallel
TELEGRAPH LINE CONNECTIONS.
R
TR
T
SPLIT JACKS
TEST BOARD JACK WIRING

Fig. 1

permit of composite working, using the ordinary 5AA retardation coil composite sets and 135-cycle ringing. The trunk line test section therefore contains jack strips for handling and testing the composite set units, as well as the repeating coils used for phantom telegraph working. In Fig. **1** is shown a schematic diagram of the jack wiring and jumper connections for a trunk line permanently wired for composite working. This permanent wiring is done in jumper fields provided in the test board section itself. All temporary changes or departures from normal are made by means of " patch " cords; double-ended tinsel telephone cords which are kept beneath the test board keyshelf (Fig. **2**). From Fig. **1**, it can be seen how temporary changes are quickly made. For instance, a patch cord plugged into the TKL jack and PXL jack, and a second cord from PXD to TKD will remove the composite set and ringer from the line and revert to repeating coil working, the phantom point being available for telegraph use at the PX jack. In the same manner a faulty composite ringer can be cut out of circuit and a spare ringer introduced using the PXD and TKD jacks of the line and the CXXL and CXXD jacks of the spare ringer, and so on for other changes and substitutions.

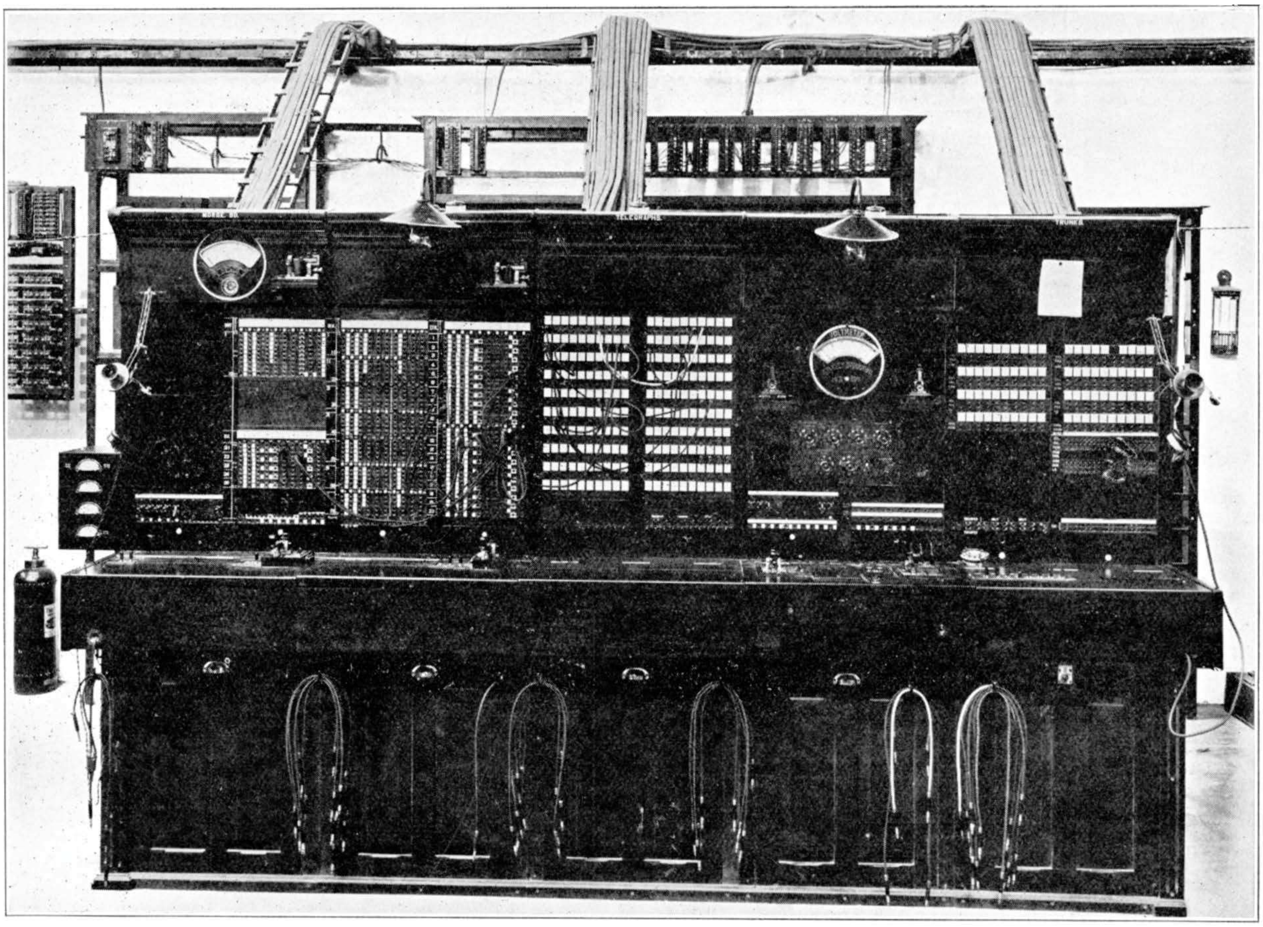


FIG. **2**.—TEST AND MORSE BOARDS.
Right to Left: Trunk Line section, Test section, Telegraph Line section, Duplex and Simplex section, Baudot and Duplex section.

Fig. **3** shows the arrangement of the trunk line jack panels, and shows how the apparatus units are designated.

Fitted on the trunk section are also break-jack strips carrying the telephone repeater balancing network units treated in a manner similar to the units of the line apparatus. Changes in the latter are, of course, followed by corresponding changes in the appropriate repeater balance units, *e.g.*, when a composite set and ringer are introduced into a line, composite set and ringer balance units are patch-corded or jumpered into the corresponding repeater network. Fig. **4** shows the break-jack arrangement at present in use for the network circuits.

In addition to the above equipment the trunk line section is also fitted with " split " jacks for separating the tip and ring wires for test purposes, Fig. **1**, and with transfer jacks wired to the Morse board to deal with temporary superimposed telegraph connections.

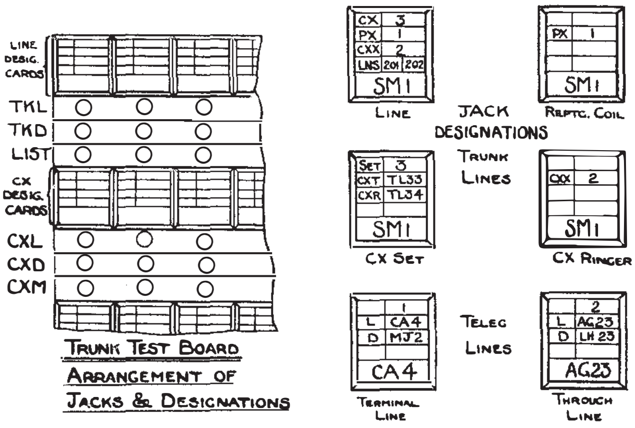


FIG. **3**.

Telegraph Lines.—The telegraph line test panel contains all direct and superimposed telegraph outlets arranged suitably for testing and making line to line cross connections. Each telegraph channel is connected through " line " and " drop " jacks as shown in Fig. **1**, while the types of jack designations used are indicated in Fig. **3**. Telephone cable pairs used for the key, sounder, and alarm wires from local offices are also brought through the telegraph section for test purposes.

Test Section.—Between the trunk line and telegraph line sections of the test board is the test position (Fig. **2**) equipped with testing instruments and speaking circuits. The instruments shown in the photograph are a testing voltmeter and milliammeter, Wheatstone bridge, closed circuit Morse sets, as well as trunk and local telephone circuits. Testing and telegraph battery taps are available on the board, all testing apparatus units and battery taps being jack-ended and used with the ordinary patch cords. Practice has shown that the use of break-jacks on the line test boards and test section greatly facilitates the whole of the testing work.

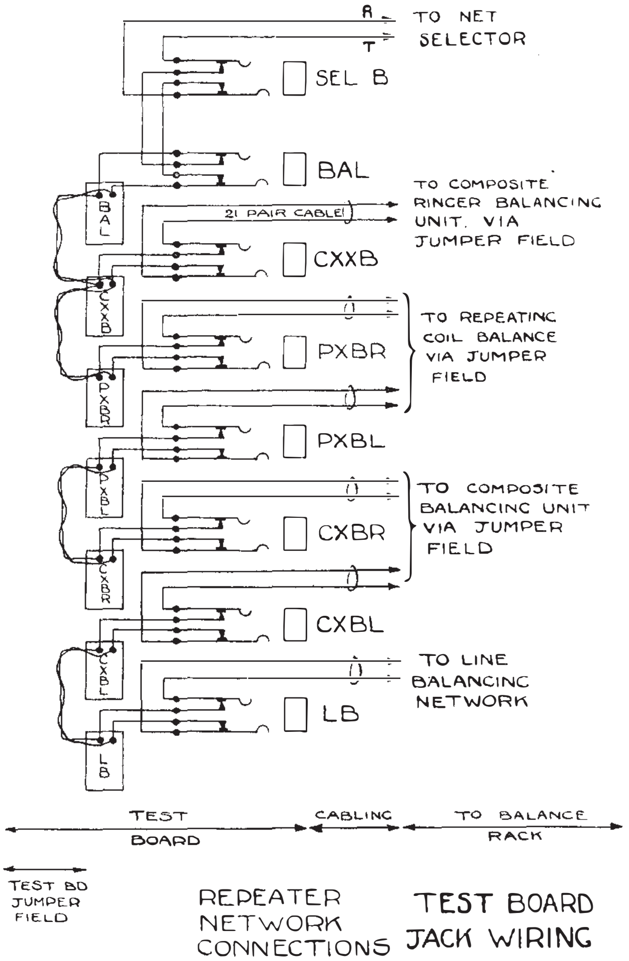

R
T
TO NET SELECTOR
SEL B
BAL
21 PAIR CABLE
TO COMPOSITE RINGER BALANCING UNIT VIA JUMPER FIELD
CXXB
TO REPEATING COIL BALANCE VIA JUMPER FIELD
PXBR
PXBL
TO COMPOSITE BALANCING UNIT VIA JUMPER FIELD
CXBR
CXBL
TO LINE BALANCING NETWORK
LB
BAL
CXXB
PXBR
PXBL
CXBR
CXBL
LB
TEST BOARD
CABLING
TO BALANCE RACK
TEST BD JUMPER FIELD
REPEATER NETWORK CONNECTIONS
TEST BOARD JACK WIRING

FIG. **4**.

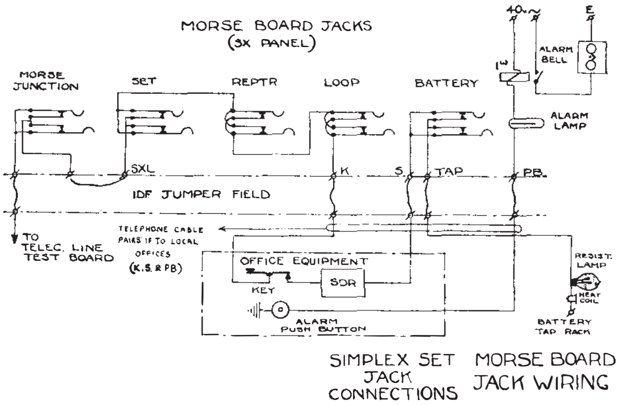


FIG. **5**.

Morse Boards and Telegraph Apparatus.—Telegraph lines are connected from the drop jacks of the telegraph test board to the Morse junction jacks of the Morse boards, and from the latter to the various telegraph sets *via* a jumper field on the M.D.F. The Morse boards are fitted as an extension to the test board, although such an arrangement is not, of course, an essential.

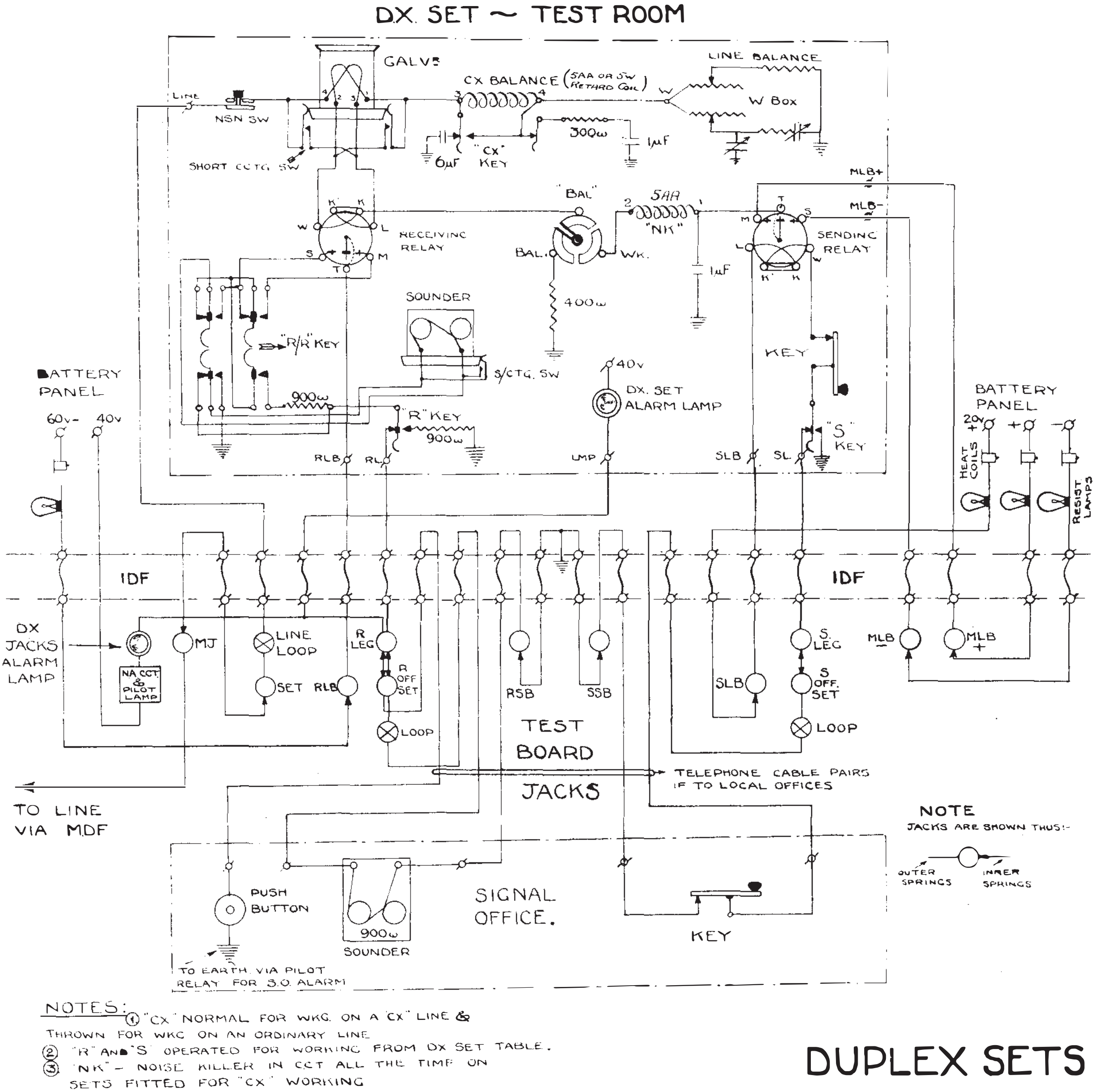


FIG. 6.

The Morse junction jacks on the Morse board provide a line to set a cross-connection field; temporary changes being made by means of patch cords while permanent wiring is jumpered. The panels of the Morse board sections are divided into units containing break-jack strips wired according to types of sets, and also provide the Morse junction jack fields, spare battery jacks for changing set battery taps, the means of monitoring on Morse wires with either a Morse set or milliammeter, and facilities for set testing.

Simplex Sets.—Fig. **5** shows the jack connections of the closed circuit simplex sets. Two closed circuit sets and two Morse junction jacks are provided in each jack strip, one panel of the Morse board being equipped with the jacks and alarm lamps for 70 sets. The office key and sounder, the alarm, line, and battery tap are connected to each closed circuit set *via* jumper fields on an I.D.F. (an ordinary block to block telephone type frame). Temporary changes of office working position, battery voltage, etc., are carried out with patch-cords, using the " Morse junction " and " set " jacks or " battery " jacks, etc. The " loop " jack is used for circuit monitoring without interfering with traffic, for testing and current measuring.

Alarm Operation.—In cases of circuit trouble, one of the signal office staff, by pressing the push button of the set concerned, lights the set alarm lamp on the Morse board. Simultaneously with the lighting of the alarm lamp, the section pilot relay and alarm bell are operated, calling the attention of the test room staff. A member of the latter, by plugging a closed circuit test set into the loop jack of the faulty set, is able to locate and deal with the fault from observations of the test set operation or from information given by the office staff. Exactly the same alarm and fault procedure is followed on the sets worked from small local offices in the city. These local offices are supplied with battery from the central telegraph office on telephone cable pairs, the central office fully controlling the circuit arrangements and testing. This arrangement has led to the saving of the batteries and battery maintenance in the local offices and has provided for expert supervision of the circuits.

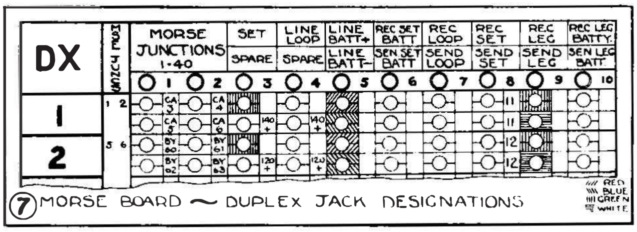


FIG. **7**.

Duplex Sets.—The duplex set panels are each equipped with break-jack strips for 20 duplex sets and associated Morse junction and spare battery tap jacks. Two strips of jacks carry four Morse junctions, two spare batteries and one duplex set as shown in Fig. **7**. The duplex set jacks are divided into three groups: line, receiving leg, and sending leg. The first group comprises the " set " jack, " line loop," and " positive " and " negative main line batteries "; the second, the " receiving leg," " receiving set," " loop " and batteries; and the third, the " sending " jacks arranged as in the receiving leg. The duplex sets are worked on the differential principle. The apparatus is mounted on tables in the test room, twenty sets per table, the units being set out for convenience in monitoring and handling. The upper portion of the table carries the relays, galvanometer, test key and sounder, and switches; while the base of the tables is fitted with composite balancing units, noise killers, and resistances (Fig. **8**). It will be

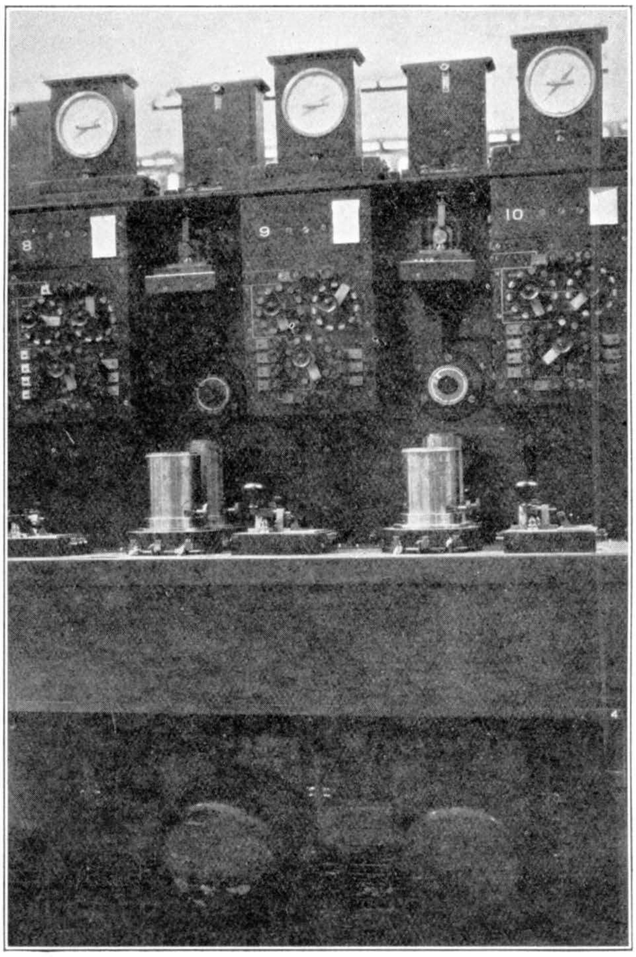


FIG. **8**.—DUPLEX TEST TABLE.

noticed that each set is fitted with a sending relay and also with a second key and sounder in series with the office equipment, which, as in the case of the simplex sets, consists of key sounder, and alarm push button, whether in the central office or in the local offices in the city.

The test room technical staff carry out the balancing, testing, and maintenance of the sets. The provision of the second sounder permits of constant supervision being maintained on the working of the circuits.

It will be seen from the duplex set connections, as shown in Fig. **6**, that the system of wiring provides great flexibility. Cross-connections with patch-cords from receiving and sending leg jacks to office receiving and sending set jacks allows any office position to work on any one of the sets. Therefore, should a set fault develop, the procedure in dealing with it is to patch-cord the office position to a spare set. The traffic channel is kept working instead of being held up while the fault is being investigated, so that no avoidable loss of circuit time results. Moreover, by the same means, temporary rearrangements of office positions to suit traffic requirements are readily carried out and office positions can be concentrated at night as required.

The provision of the sending relay in each set has a number of advantages. The office set wiring is simple and has to carry only low voltages, a quicker pole change is obtained, thus maintaining a better balance. Furthermore, each set is made universal — it may be utilised as a regular duplex terminal set, as half of a duplex repeater or, as the duplexing unit for machine telegraphs. To make up a repeater with this system of working is a matter of a moment. Two patch-cords, one from the receiving leg jack of the first set to the sending leg jack of the second set, and the second cord in the reverse manner are plugged in on the Morse board and on each set the " repeater " key is thrown to complete the operation. This feature is found to be very useful both for ordinary repeater working and for repeating on temporarily built-up circuits, such as may be required during cases of line breakdown. Spare duplex sets are used to build the repeaters or, if there are not sufficient spare sets, repeaters are made from sets released from unimportant short lines, which are reverted to simplex working.

It will be seen from the jack connections shown in Fig. **6** that the loop jacks fitted in the line, sending and receiving legs provide a ready means for monitoring, measuring currents and testing from the Morse board. Battery changes to deal with departures from normal conditions are made by the use of the main battery jacks and the spare battery taps available on the board.

Keys are fitted on the sets, (1) to allow the composite balance to be switched in or out of the circuit, as required by the line conditions, *i.e.*, " CX " key; (2) to allow the office equipment to be switched out of the circuit for testing and speaking from the set—" R " and " S " keys; and (3) to provide means for balancing and repeater working—" BAL " and " R/R " keys.

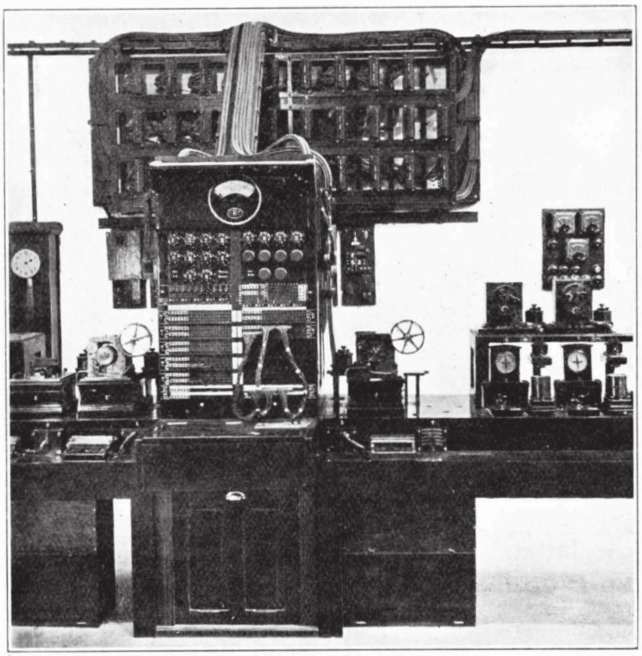


FIG. **9**.—ARRANGEMENT OF BAUDOT TEST BOARD AND BAUDOT SETS.

Fig. **6** also shows how the permanent set arrangement of batteries, office position, etc., are made in the I.D.F. jumper fields and also shows the alarm system, and the battery tap protection as provided on the battery panels, etc.

The alarm operation is similar to that already described in simplex working, but a second additional alarm lamp is provided over the DX set, as well as the one on the Morse board. Patch-cord changes of set to office positions are arranged to change the alarm wires as well as the instrument connections—" R leg " and " R set " jacks.

Baudot Sets.—The Morse board Baudot equipment consists of the alarm lamps and jacks (shown in Fig. **10**) wired one set per jack strip. Connections from set to line are made from the " set " jacks to the Morse junctions; the battery taps required are jumpered or patched to the battery jacks. The loop jacks provide means for line current measurement and the " DX MAM " and " RL " jacks are used for duplex connections. The cabling from the Morse board jacks terminates on tag blocks on the I.D.F. From the latter, jumper fields connect to the test board, battery taps, and to blocks cabled to the Baudot test board.

The Baudot section of the Morse board is equipped with double current Morse sets for speaking on Baudot lines, also with local telephone sets to the signal office, and with the Morse board voltmeter—milliammeter—Fig. **2**.

Baudot Test Board and Baudot Apparatus.—It was mentioned in the previous description of the New Delhi Signal Office, that arrangements were in progress for the operation of Baudot telegraph sets on a remote control basis. This system has now been investigated and installed and the arrangement of sets and Baudot test board at present in use is shown in Fig. **9**.

Ten simplex two-arm distributors and line equipments with four test receivers and keyboards are mounted on a table with a test board in the centre. The signal office is equipped with receivers, keyboards and alarms, cabled to the test room I.D.F. and jumpered as required for permanent working to the " office " side of the 20 way break jack strips on the test board.

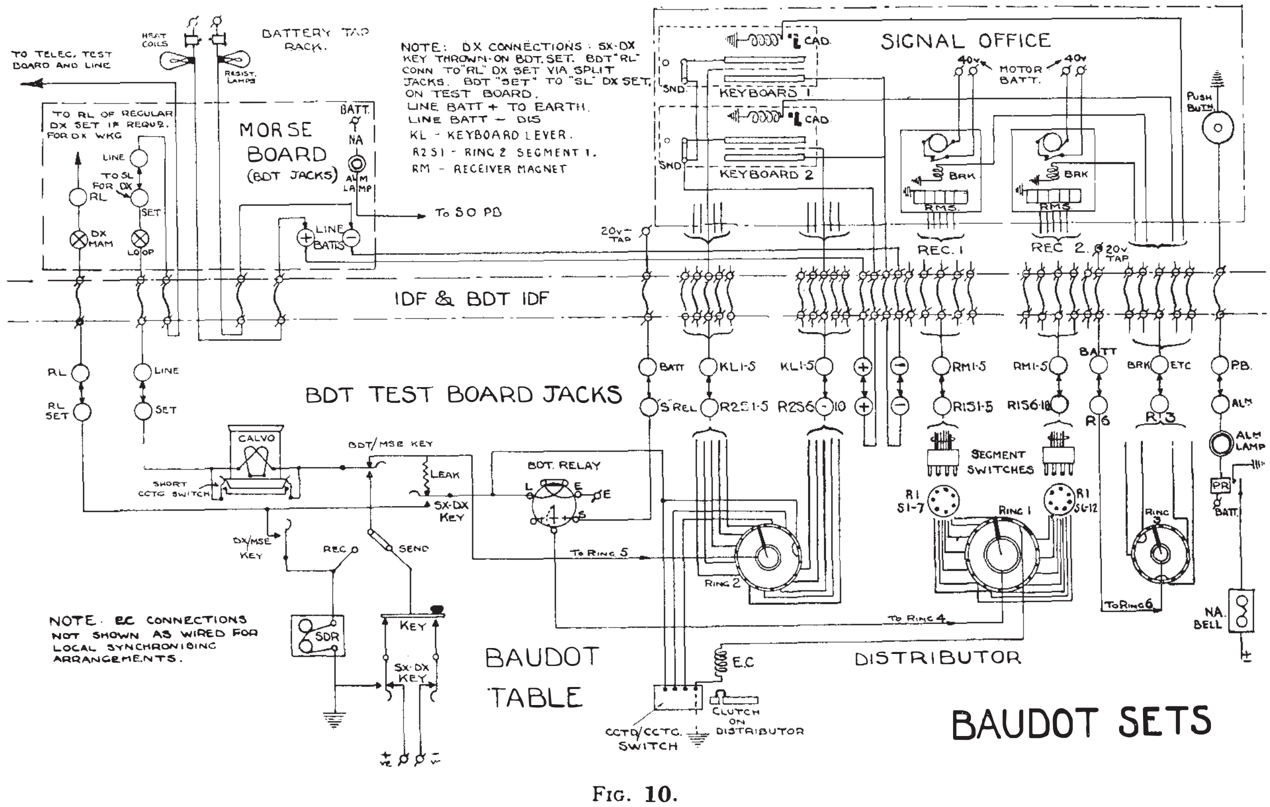
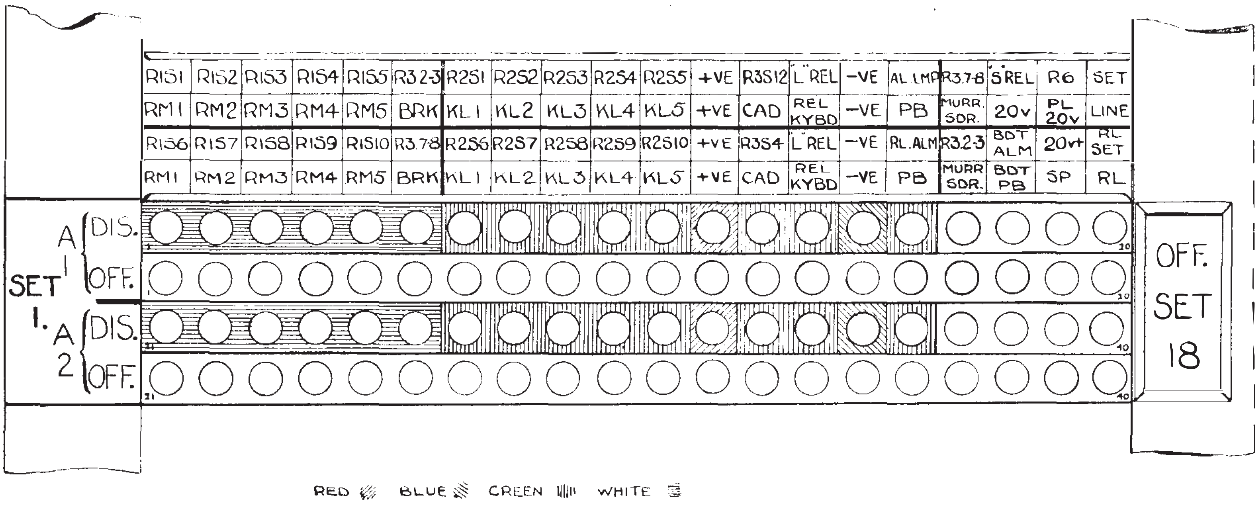


Fig. **10**.

The " distributor " side jacks are wired to the set segments, line apparatus, etc., the inner springs of the " office " and " distributor " jacks being looped.

From the jack connections (Fig. **10**) it can be seen that the use of patch-cords enables any office position to be cross-connected to any distributor, and the receiving arms and keyboards of each set to be crossed and varied at will. Multiple patch-cords are used, six-way plugs for receiving arms and five-way plugs for keyboard comnnections, two five-way cords being used for each keyboard. The test set receivers and keyboards are jack-ended on the test board and used with patch-cords. A test receiver and keyboard are shown plugged into set 7 in Fig. **9**.

The flexibility obtained by the use of the test board jack field permits of a change of distributors to be made in case of a set fault without altering the office position. Baudot positions can be concentrated in the signal office as traffic decreases in the evening and lines revert to Morse working, without change of distributors or loss of synchronism. It is of considerable value to be able to interchange quickly the local copy receiver and base with the incoming arm unit without loss of synchronism or alteration of circuit conditions. When cases of persistent trouble are experienced on the moderator of the incoming receiver base, the faulty unit is crossed with the local copy receiver, to perform the comparatively unimportant work of printing a local record, until the trouble is removed.



R1S1	R1S2	R1S3	R1S4	R1S5	R3 2-3	R2S1	R2S2	R2S3	R2S4	R2S5	+VE	R3S12	"L" REL	−VE	AL LMP	R3.7-8	"S" REL	R6	SET
RM1	RM2	RM3	RM4	RM5	BRK	KL1	KL2	KL3	KL4	KL5	+VE	CAD	REL KYBD	−VE	PB	MURR. SDR.	20v	PL 20v	LINE
R1S6	R1S7	R1S8	R1S9	R1S10	R3.7-8	R2S6	R2S7	R2S8	R2S9	R2S10	+VE	R3S4	"L" REL	−VE	RL.ALM	R3.2-3	BDT ALM	20v+	RL SET
RM1	RM2	RM3	RM4	RM5	BRK	KL1	KL2	KL3	KL4	KL5	+VE	CAD	REL KYBD	−VE	PB	MURR SDR.	BDT PB	SP	RL

⑪ **BAUDOT TABLE—JACK DESIGNATIONS.**

The test board jack connections are arranged so that when a patch-cord from a test receiver is plugged into a set, the test and office receivers work in parallel. This arrangement serves two purposes—(1) the Baudot Supervisor in the test room is able to monitor on the sending and receiving arms of the sets and check incoming and outgoing signals without interfering with the traffic, and (2) when the supervisor is attending to a fault at the test board, the office staff are kept informed as to what is happening by taking observations on their receivers.

Carpentier type keyboards are used, but the office keyboard switches are permanently set to " send," the condition required for reception being obtained by the use of a multiple plug on the test board jacks. The plug connects the sending segments to the line terminals of the relay. This saves time by eliminating changes of office apparatus. These " receive " plugs are shown in use on sets 4 and 5 in Fig. **9**.

The test board is fitted with a combined voltmeter and milliammeter with jack-ended connections, the instrument being brought into use by means of a doubled plug and cords. Line currents are measured by plugging into the " line " and " set " jacks. Similarly, currents in each branch of the receiving and sending arms can be checked independently.

Interposed between the distributor receiving segments of ring 1 and the receiving arm jacks are radial plug switches which permit of the receiving segments being quickly moved from segments 6-10 to 7-11 or 8-12, when this is necessary owing to the retardation on long lines —" segment switches " in Fig. **10**.

Alarm lamps are provided for each set, operated from the office push button, to call the attention of the Baudot supervisors in case of trouble; keys on the test board are arranged to light a lamp and give an alarm in the signal office, when the set is ready to work after a fault. In cases of faults of short duration, the recommencement of the keyboard cadence on the office keyboard when the test keyboard is removed gives the indication that the fault has been rectified.

The alarm procedure followed is similar to that previously described in the Morse simplex set operation, the test receivers and keyboard being used to investigate troubles not obviously line faults.

Retransmitter working.—As in the case of Morse duplex sets, any two Baudot sets can be jumpered or patch-corded together to form a retransmitting repeater. This necessitates, of course, that the two sets be first locally synchronised. Special 20-way jack strips are fitted on the test board for retransmitter working. To these are wired the connections to the coils, levers, battery taps and release magnets of retransmitting relay units; connections to ring three segments 6, 11 and 13; the electric corrector of each of the ten sets, and sets of " loop " jacks. Sets are locally synchronised by cross-connecting the required jacks with short single patch-cords in this jack field as shown in Fig. **12**.

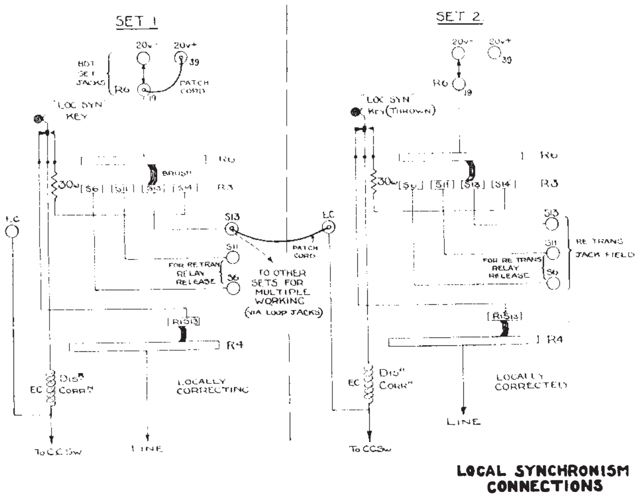


FIG. **12**.

The diagram shows that one set is allocated as the locally correcting set. The battery to ring 6 on this set is changed from 20 volts negative to 20 volts positive by means of a looped double plug joining jack 19 to jack 39 in the set jack strips. In the retransmitter jack field a patch-cord is plugged from the ring 3) "segment 13" jack of the controlling set to the "EC" jack of the set to be synchronised. On the latter, the " Local Synchronism " key is thrown and the speed adjusted to give an ordinary correction on the electric corrector. The correcting current is received when the batteries of opposite polarity meet on the beginning of segment 14 on the corrected set and the brushes of the latter are retarded to segment 13. Other sets can be similarly synchronised locally by plugging the cord from the segment 13 jack of the controlling set to loop jacks and from the latter group as many cords as there are sets to be synchronised are connected to the various EC jacks. Sets can be locally synchronised in a very short time.

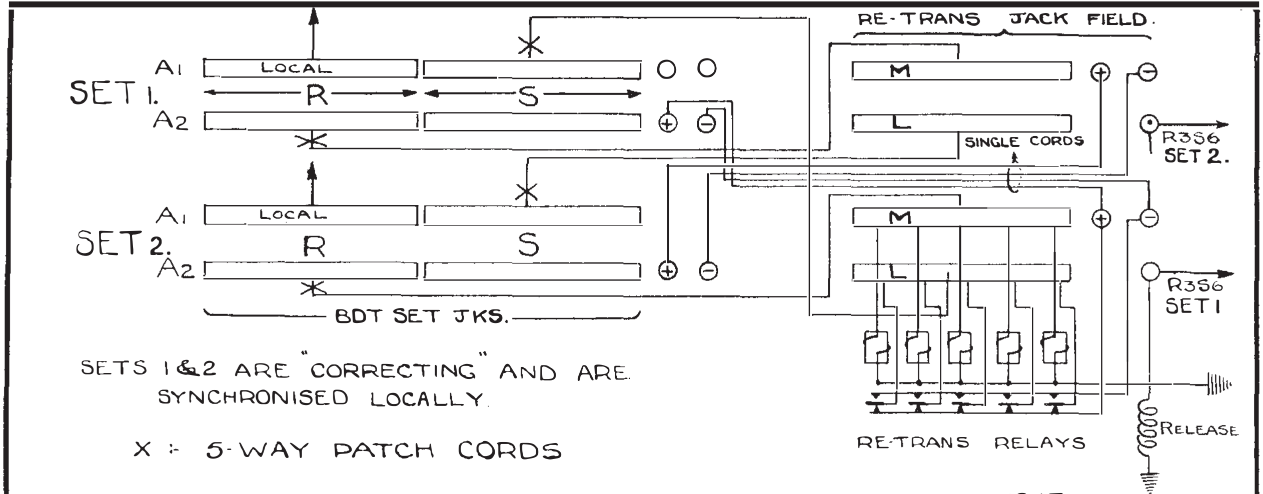
The two sets of a retransmitter are used as " correcting " sets in relation to the distant terminal stations. The retransmitting relays are jumpered to the sets, or connected with patch-cords as follows:—Five-way cords are used to connect the receiver segments of the receiving arm of the first set to the magnets of one retransmitter relay and the levers of the latter to the sending segments of the second set. Single cords connect the positive and negative batteries from the second set jacks to the battery jacks of the relays, and the ring 3 " segment 6 " jack to the release jack of the relays. Connections in the reverse manner from set 2 to a second retransmitter relay unit complete the repeater, Fig. **13**.

The retransmitted signals are monitored with the test receivers in the receiver jacks of the sending arms in the usual way. In the same way that duplex Morse repeaters are built up to deal with line emergencies so Baudot retransmitting repeaters can be made up. If necessary, unimportant short Baudot lines are reverted to Morse working to set free apparatus to provide the retransmitting repeaters on temporary long and important circuits. The system has the advantage that standard terminal sets are used for all types of work, which results in a saving in the provision of special sets and spares.

Multiple working.—The same system of local synchronism is used for the simultaneous sending on a number of sets from one keyboard for multiple press transmission. The sending arms of the sets concerned are looped to the signal office keyboard from which it is desired to send and the line battery voltages are equalised, Fig.

14. The arrangement facilitates the disposal of long press messages booked for a number of stations and also frees office staff for other work. The incoming receiving arms of the sets concerned continue work in the normal way.

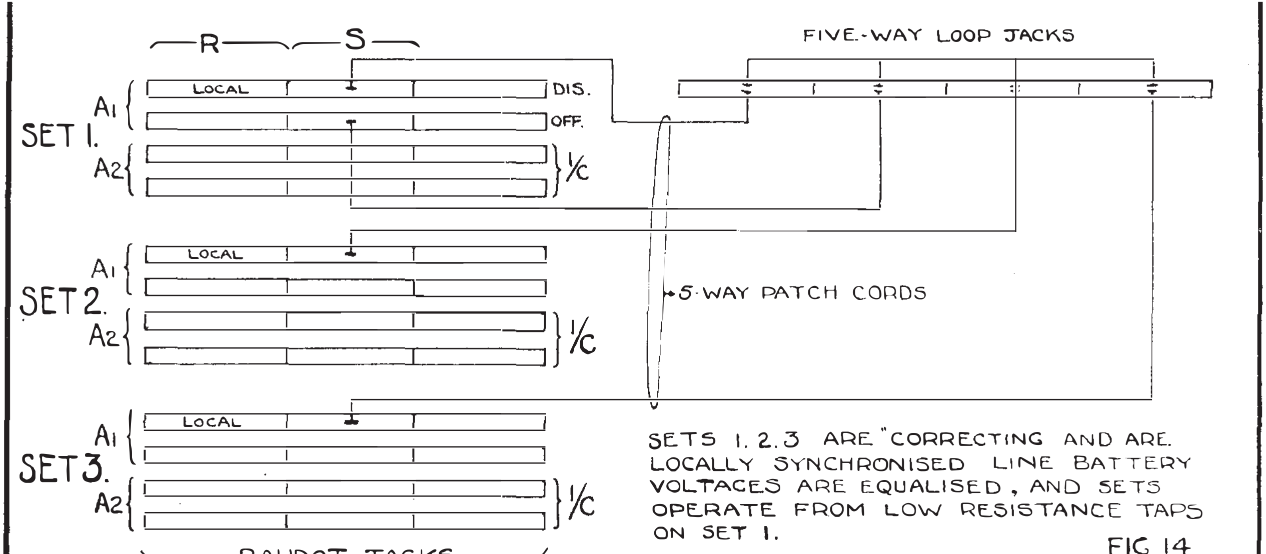
PATCH-CORD CONNECTIONS—SX BAUDOT REPEATER 2-ARM



SETS 1 & 2 ARE "CORRECTING" AND ARE SYNCHRONISED LOCALLY.

X :- 5-WAY PATCH CORDS

FIG. 13.



SETS 1, 2, 3 ARE "CORRECTING AND ARE LOCALLY SYNCHRONISED LINE BATTERY VOLTAGES ARE EQUALISED, AND SETS OPERATE FROM LOW RESISTANCE TAPS ON SET 1.

FIG 14.

SIMPLEX BAUDOT MULTIPLE WORKING (2-ARM).

Duplex working.—Baudot sets are duplexed by means of jumper or patch-cord connections on the Morse board connecting the Baudot set to one of the regular Morse duplex units. In the system in use at present, the positive line battery jack of the Baudot set jacks is earthed, the negative left disconnected, and the receiving leg jack of the Baudot jacks connected to the RL jack of the duplex set. The keyboard thereby operates the sending relay of the duplex set and the receiving circuit is connected to Ring 4. A loop jack (DX/MAM) in the receiving leg is provided in the Baudot jacks for obtaining a finer adjustment of the line balance after the ordinary hand balance has been found. A DX-

SX key on the Baudot set is thrown to change from simplex to duplex conditions. Fig. **10**.

Miscellaneous Apparatus.—Of the Test Room miscellaneous apparatus, it may be of interest to mention the type of battery tap racks in use. All battery taps are fed through 20-unit panels, each tap connection passing from a bus bar through a disconnecting type of heat coil and protecting resistance lamp to the I.D.F., where the tap is jumpered to the set block required. The heat coil is arranged to operate at slightly less current than the MDF standard telephone type heat coil in order that fleeting line faults may disconnect superimposed telegraph channels rather than disconnect the trunk speech circuit.

Routine Testing.—All the test room apparatus is subject to a rigid system of weekly routine testing in a manner similar to that used in automatic telephone exchanges. The testing is usually performed by the night staff, and ensures the maintaining of all working and spare apparatus in a state of efficiency. Fault records are kept to indicate the standard of apparatus operation and to facilitate the tracing of recurring faults and detection of worn apparatus. In practice it is found that Morse apparatus faults are extremely few. Lost time on Baudot circuits due to apparatus faults is kept at a low figure by the application of routine testing and by the flexibility introduced which permits of changing a faulty instrument quickly.

Signal Office Fittings.—The simplicity of the office fittings has enabled a neat arrangement of apparatus to be adopted. Baudot sets can be fitted two per table where there was room for only one previously.

Power and Battery Room Apparatus. — A radial type of change-over switch is fitted in the telegraph battery discharge leads. This is a simple reversing switch, which interchanges and reverses the two halves of the battery so as roughly to equalise the discharge on all cells. The battery is tapped every twenty volts, and line currents, etc., are adjusted by variation of voltage rather than by battery tap resistance.

Test Wires.—Among the future developments of the test room system of operation is the provision of a " test wire " between station test boards. This channel is intended to be reserved for service messages ordering line crossings, etc., relieving the ordinary channels of non-revenue earning loads. As messages will be received directly, the delay in completing service operations is expected to be reduced to a minimum. A thermostat calling device has been designed for use on such closed circuit lines to give a positive lamp and alarm bell calling signal.

In conclusion, following the successful establishment of the test room system in New Delhi, it has been decided to fit an adjacent large office in the same manner. On the experience which will then become available the desirability of the future extension of the system to all the larger offices of the Department will be considered.

COMPOSITED TELEGRAPH AND TELEPHONE WORKING.

J. M. Owen, A.M.I.E.E., and J. A. S. Martin.

INTRODUCTION.—Superposing telegraph circuits on the unloaded phantoms of telephone pairs by means of transformers is a method that is well known to communication engineers. When, however, the phantom circuits are loaded and therefore not available for superposing telegraphs, the problem becomes more complicated. It is the object of this article to show how a loaded underground circuit can be successfully used for simultaneous telegraph and telephone working. This system is known as Composited Working and, for reasons that will be obvious later, is sometimes referred to as Sub-Audio or Infra-Acoustic Telegraphy.

The frequency band necessary for high grade telephone transmission is from 200 to 3000 cycles per second. It will be apparent that the range from 0 to 200 c.p.s. can be utilised for telegraph transmission, provided that some device is used to prevent the low frequency telegraph signals producing noise in the telephone circuit. A device such as this should not appreciably degrade the telephone transmission.

A square-shaped telegraph signal can be

shown by means of Fourier's Integral to be made up of a fundamental frequency and a number of harmonics, some of the latter being in the frequency range required for telephone transmission.

In order therefore to effectively separate the telephone and telegraph signals it will be first of all necessary to suppress the higher harmonics of the telegraph signals before such signals are impresssed on the line. For example, a Wheatstone speed of 62.5 words per minute—*i.e.*, a fundamental telegraph frequency of 25 c.p.s.—would contain harmonics in the range between 200 and 300 c.p.s.

The telegraph problem therefore consists essentially in transmitting telegraph signals to line so as to effectively operate a telegraph relay at the distant end and to be free from harmonics of telephone frequency. Experiment has shown that signals whose shape approximates to a sine wave are sufficient for this purpose. In order to smooth or round-off the signals a low-pass filter is used in the telegraph circuit. Such a filter is made to suppress all frequencies higher than the calculated cut-off point, usually about 40 to 60 c.p.s.

For the purpose of blocking out the low telegraph frequencies from the local telephone circuit a high-pass filter is inserted in series with the line and telephone. The cut-off frequency of this filter, as previously mentioned, should be 200 c.p.s. As the name suggests, this filter suppresses all frequencies below the cut-off value.

A low-pass filter is necessary at the receiving end, for although there is no question of smoothing the signals received from line, another cause of disturbance has to be provided for. The actuation of the relay armatures between the pole-pieces causes variations of flux and produces currents of telephone frequency. There is also a possibility of impulses being transmitted to the telephone circuit by virtue of the capacity of the relay winding with respect to its core.

Further, if the relay used at the receiving end is a " G " relay, currents are transmitted from the tongue to earth through the " G " windings. These currents cause disturbing impulses to be transformed back into the telephone circuit through the line windings of the relay.

It will be appreciated that the low-pass filter will cause considerable sparking at the contacts of the transmitting relay and therefore spark quench devices are fitted. Sparking also causes disturbances in the telephone circuit and it has been found beneficial to equip both the transmitting and receiving relays with spark quench devices.

Before describing the system in detail it will be of interest to enumerate the conditions that have to be met, both as regards the telephone and the telegraph case.

Considering the telephone case first, the several conditions to be met in the Department's underground network can be classified as follows: —

(*a*) Short telephone circuits worked on loops without transformers and using C.B. signalling.

(*b*) Short telephone circuits without transformers, using magneto signalling.

(*c*) Telephone circuits, side-and-phantom-loaded, using modified C.B. signalling.

(*d*) Telephone circuits, with or without two-wire repeaters, side-and-phantom-loaded, using magneto signalling.

(*e*) Telephone circuits, side-and-phantom-loaded, used for two-wire repeatered circuits, and using V.F. signalling.

(*f*) Telephone circuits, side-and-phantom-loaded, used for four-wire repeatered circuits, and using V.F. signalling.

(*g*) Telephone circuits, side-loaded only, used for either two or four-wire repeatered circuits.

(*h*) Telephone circuits in which the loading coils are of the iron wire core type.

In the case of (*a*), (*b*) and (*g*) the phantom circuit is not required for telephone transmission, and it would be more economical to superpose by the transformer method. As regards (*g*) the low frequency telegraph signals would be byepassed at the telephonic repeaters by connecting the mid-points of the line sides of the transformers either side of the repeaters. It will be apparent that any form of battery signalling would have to be replaced by either magneto or voice frequency signalling.

As regards (*c*) to (*f*), composited working would be resorted to, as in these cases the phantoms are required for telephone purposes.

The low-pass filter admits all frequencies up to, say, 60 c.p.s., depending of course on the design of the filter. Therefore it will be obvious that magneto signalling would interfere with the telegraph signals. Also, battery signalling could not be used and under these circumstances voice frequency signalling must be adopted. Where all the pairs in the cable are not required for composited working, a modified type of battery signalling could be used where the signalling is composited on a single wire to earth, instead of round the loop. A smoothing device is used to smooth the signals before they are impressed on the line, in fact the signalling could really be described as composited signalling. Where the phantoms are not required for telephone working, two quads would provide signalling for four telephone circuits and leave two side circuits for compositing the telegraph. Where the phantoms are in use for telephone working, four quads will provide signalling for eight side circuits and four phantoms, and leave two side circuits for compositing the telegraph.

In the case of repeatered telephone circuits, both two- and four-wire, it will be necessary to have both high- and low-pass filters either side of the repeater. The low frequency telegraph signals will be byepassed by connecting the two low-pass filters together. Where two-wire repeaters are used, it will be necessary to modify the line balance as the addition of the filters will slightly change the impedance-frequency characteristic of the circuit.

The iron-wire-cored loading coils are not suitable for composited working as they tend to become magnetised with the flow of direct current. This produces modulations in the speech currents. As, however, the greater number of coils in use at the present time are of the dust-core type this is not a matter for serious consideration.

In addition to the aforementioned conditions there is the question of the different types of loading. Although the majority of loading is medium heavy, *i.e.*, 177 mH coils in the side circuits and, where loaded, 106 mH in the phantoms at 1.125 miles spacing, there are a number of cables with the same value coils, but spaced at 1.6 miles. There are also cases in which both the coils and spacings are different from those mentioned above.

As the filter network must match the impedance of the particular cable with which it is associated, it will be readily appreciated that the values of the capacity and inductance components used will require modification for each particular type of cable.

Telegraph Case.—In considering the telegraph case, the following points require consideration:—

(1) The use of a single wire using earth return.
(2) Loop working.
(3) Working round the loop with the " B " line earthed at the sending end.
(4) Simplex or duplex working.
(5) Type of apparatus to be used.

The use of single-wire earthed circuits tends to unbalance the wires of a pair.

Loop working presents two difficulties. Firstly, separate insulated batteries are required for each circuit, and, secondly, two relays are required at the sending end to reverse the battery across the loop. This latter is termed double commutation. In the case of circuits with no telegraph repeaters the relays can be adjusted to operate reasonably alike for satisfactory working, but where repeaters are in circuit the satisfactory adjustment of the relays throughout the circuit is difficult, and gives rise to cumulative bias. As a compromise between single wire earthed, and loop working, the " B " line is earthed at the sending end so that there is a close approximation to loop working, whilst permitting the use of a single transmitting relay, and the ordinary universal telegraph battery. In this case a device is necessary to prevent interference with other circuits in the cable due to the surge caused in one leg of the loop by the application of the battery. A transformer is so connected that a surge in one leg will be repeated into the other leg and so prevent a condition of unbalance.

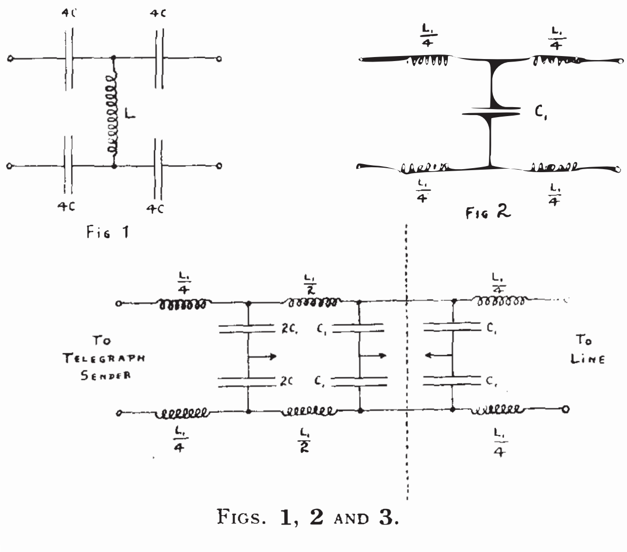
The question of simplex or duplex working depends upon the number of pairs available and the telegraph facilities required. Where sufficient pairs are available, it is better to use a pair for transmitting in each direction, as troubles due to the duplex balance will be eliminated. Two pairs would therefore give the same facilities as a duplex circuit.

Composited working is, by virtue of the limitations to speed imposed by the low-pass filters, essentially suitable for teleprinter working. The speed of the latest type is 25 c.p.s., which is considerably below the cut-off point of the low-pass filter. From this it will be seen that even on long lines a fair working margin exists.

Filter Details.—It has already been mentioned that in this system high- and low-pass filters are used. The filter values were calculated by the use of well-known formulæ, but it might be of interest to show in a simplified form how this was done. The values of the filter components depend upon the type of circuit used, so that the electrical constants of the circuit must be known before the calculations can be made.

In one particular case the circuit used was a 40-lb. medium heavy loaded one, *i.e.*, 177 millihenry coils in the side circuits and 106 mH coil in the phantom circuit, spaced 1.125 miles apart. Further, the characteristic impedance $Z_0 = 1556 \backslash 1^\circ 56'$ ohms at $\omega = 5000$ rads. per sec.

Consider the case of the high-pass filter. It was desired that this filter should have a cut-off frequency $f_c = 200$ cycles per sec. ($\omega_c = 1256$ radians per sec.). That is to say, all frequencies below 200 c.p.s. must be suppressed.



FIGS. **1**, **2** AND **3**.

Fig. **1** shows a single section (T circuit) high-pass filter. Capacities form the series elements, and an inductance forms the shunt element.

$$\text{Now } \omega_c = \frac{1}{2\sqrt{LC}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where $\omega_c = 2\pi f_c = 1256$ rads. per sec.

$$\text{and } Z_0 = \sqrt{\frac{L}{C}}\sqrt{1 - \frac{1}{4\omega^2 LC}} \quad \ldots\ldots\ldots\ldots (2)$$

$$\text{from (1) } C = \frac{1}{4\omega_c^2 L} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

and substituting (3) in (2) we get

$$Z_0 = 2\omega_c L\sqrt{1 - \left(\frac{\omega_c}{\omega}\right)^2}$$

$$\therefore \; L = \frac{Z_0}{2\omega_c\sqrt{1 - \left(\frac{\omega_c}{\omega}\right)^2}} \quad \ldots\ldots\ldots\ldots (4)$$

$$\therefore \; L = \frac{1556}{2 \times 1256\sqrt{1 - \left(\frac{1256}{5000}\right)^2}}$$

$$= 0.642 \text{ henry}$$

$$\text{and } C = \frac{10^6}{4 \times (1256)^2 \times 0.642} = 0.2465\ \mu\text{F}.$$

Whence the capacity element becomes 4 × 0.2465 = 0.986 μF. and the inductance element becomes = 0.642 henry.

The inductance was obtained with about 1500 turns of No. 24 S.W.G. D.S.C. wire on $\frac{3}{4}''$ stampings and with an air gap of about 60 mils.

Consider now the case of the low-pass filter. In this particular instance $Z_0 = 2000$ ohms at 25 cycles per sec. ($\omega = 157$ rads. per sec.). The working speed of a Teleprinter 3A is approximately equal to 25 cycles per second. It was desired that this filter should have a cut-off frequency of 60 cycles per sec. ($\omega_c = 377$ rads. per sec.)—that is to say, all frequencies above 60 cycles must be suppressed.

Fig. **2** shows a single section (T circuit) low-pass filter. Inductances form the series elements and a capacity forms the shunt element.

$$\text{Now } \omega_c = \frac{2}{\sqrt{L_1 C_1}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where $\omega_c = 2\pi f_c = 377$ rads. per sec.

$$\text{and } Z_0 = \sqrt{\frac{L_1}{C_1}}\sqrt{1 - \frac{\omega^2 L_1 C_1}{4}} \quad \ldots\ldots\ldots\ldots (6)$$

$$\text{from (5) } C_1 = \frac{4}{L_1 \omega_c^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

and substituting (7) in (6) we get

$$L_1 = \frac{2Z_0}{\omega_c \sqrt{1 - \left(\frac{\omega}{\omega_c}\right)^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

$$\therefore \quad L_1 = \frac{4000}{377 \sqrt{1 - \left(\frac{157}{377}\right)^2}}$$

$$= 11.65 \text{ henries.}$$

$$\text{and} \quad C_1 = \frac{4 \times 10^6}{11.65 \times (377)^2} = 2.42 \ \mu\text{F}.$$

Whence the inductance element becomes 2.91 henries and the capacity element becomes 2.42 μF.

The inductance was obtained with about 2200 turns of No. 24 S.W.G. D.S.C. wire on $\frac{3}{4}''$ stampings, and with an air gap of about 10 mils.

In the case of the low-pass filters it is necessary that the inductances should be carefully balanced in order to keep the crosstalk, and particularly the side to phantom crosstalk as low as possible. For a similar reason the condensers in the high-pass filters should be carefully balanced. It is also essential that the effective resistance values in these cases should be as close as possible.

It has previously been mentioned that it is necessary to smooth the telegraph signal wave shape before transmitting to line. For this purpose a smoothing circuit is used. This is nothing more or less than a low-pass filter. It will be readily realised that as the smoother unit is joined directly to the low-pass filter it is essential that the characteristics of this filter should not be affected. The smoother unit is therefore so designed that when it is joined to the line or filter unit, the whole becomes a two-section filter with characteristics similar to that of the single section low-pass filter.

Fig. **3** shows the completed low-pass filter circuit. The part to the right of the dotted line is associated with the line unit, whilst the part on the left is the smoother unit. The values of the components are so arranged that the circuit has the same characteristics as those of the filter shown in Fig. **2**. The condensers in Fig. **3** are split as shown, in order to standardise the line unit, and this enables the filters to be joined through to form the telegraph bye-pass at the telephone repeater stations without any alterations being required.

Detailed Description. — The compositing apparatus comprises a telegraph unit, a smoother unit and a line unit.

As a smoother unit is only required at a transmitting point, which may include a telegraph repeater, it is mounted on the same rack as the telegraph apparatus.

The telegraph unit carries the transmitting and receiving relays, together with associated apparatus. The relays used are of the P.O. Standard type, fitted with flexible spring tongues and with cores annealed in hydrogen. This type is particularly free from contact chatter and residual magnetism and is designed for efficient operation at low current values. The receiving relay is of the " G " type, the resistance and capacity values being fixed so as to give steady reversals at 25 c.p.s. Both relays are fitted with spark quench circuits. Four galvanometers are provided, two for the local circuits to and from the telegraph office, and two for the cable circuits, send and receive. These galvanometers are of the moving coil differential type, specially made for panel mounting. The scale is calibrated to give a deflection of 10 milliamps either side of zero with both coils in series. One leg of the loop is taken through each coil. Resistance is added in each leg of the cable send circuit for the purpose of regulating the steady line current which is kept at a value of 3 to 4 milliamps. It will be seen from Fig. **4** that a 300 ohms coil is in series with the B leg regulating resistance to compensate for the 300 ohms battery resistance and so preserve the balance of the circuit.

As previously mentioned a surge or kick transformer is also inserted in the transmitting circuit.

The line unit comprises two high-pass filters for the side circuits and two low-pass filters, as well as one high-pass filter for the phantom circuit. The line transformers are also mounted on this unit, and in the case of two-wire circuits additional transformers are provided for the balance circuits. Such a unit equips the two pairs of a quad in a multiple twin cable.

It will be obvious that in the case of two-wire circuits a line unit will be associated with both the telegraph send and receive circuit. Where, however, four-wire circuits are composited, a line unit will serve two sending circuits, the receiving circuits being served by the line units associated with the " Returns " which will be in a different balancing group in the cable.

Fig. **4** shows a send and receive telegraph circuit, using single commutation composited on two two-wire repeatered telephone circuits. The operation of the circuit is as follows:—Signals from the telegraph office operate the transmitting relay. From the tongue of this relay with earthed battery on its contacts, the signals are repeatered into the A line of the telephone loop *via* the regulating resistance, one coil of the kick transformer, one coil of the differential milliammeter, A line of smoother unit and A line of low-pass filter. The surge in the A leg which will take place when the voltage is first applied will be repeated in the " B " leg by means of the kick transformer. The signals pass along the line and at the telephone repeater station, they are byepassed through the coils of the low-pass filters. The high-pass filters, as at the sending end, prevent the telegraph signals from entering the telephone repeater.

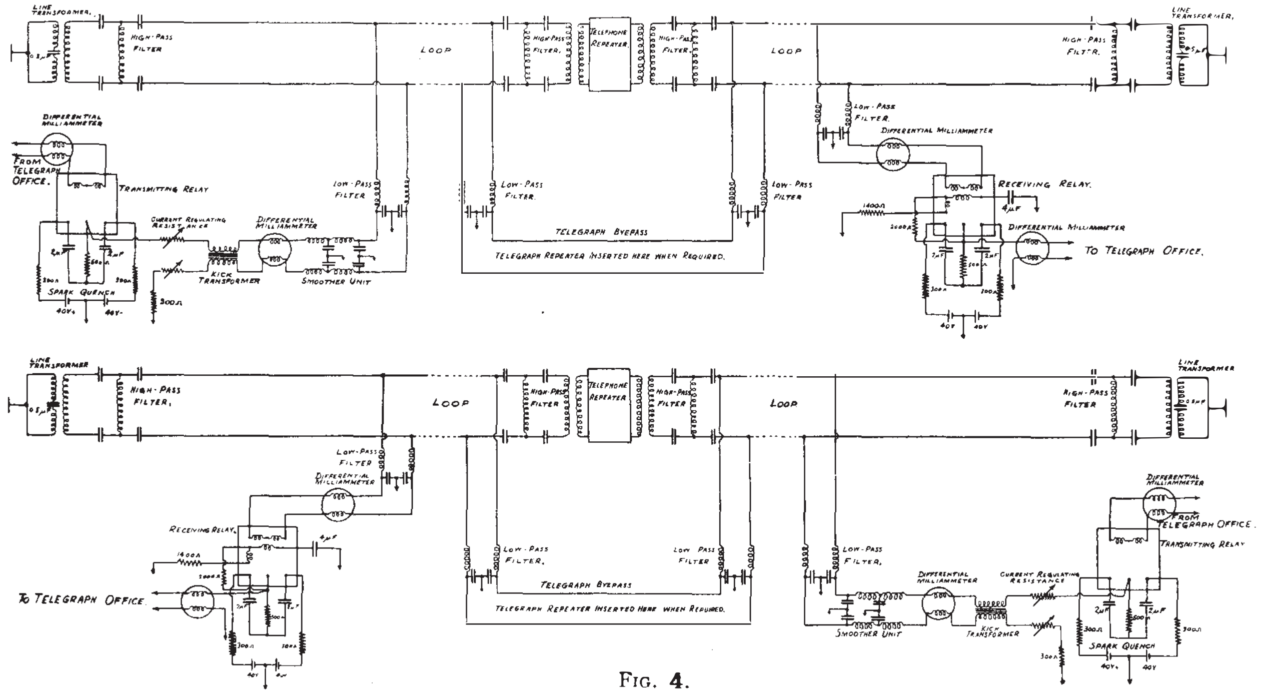


FIG. **4**.

After byepassing the repeater, the signals again pass to line and at the receiving end pass through one coil of the low-pass filter, both coils of the telegraph receiving relay and back to the B line through the other coil of the low-pass filter. As at the sending end, and at the telephone repeater these low frequency signals are blocked from entering the telephone circuit by virtue of the high-pass filter. After passing to the " B " line the signals are again byepassed at the telephone repeater and eventually find earth at the sending end *via* one coil of the low-pass filter, B line of smoother unit, one coil of differential milliammeter, one coil of kick transformer, regulating resistance, and 300 ohms resistance.

At the receiving end the signals are repeated to the telegraph office by means of the tongue and earthed battery on the battery contacts of the relay.

Speech currents pass to line *via* the high-pass filter, are amplified through the telephone repeater and received at the far end *via* the high-pass filter. In all cases these voice frequency currents are blocked from the telegraph circuit by means of the low-pass filters.

It will be apparent that as in this particular case two-wire telephone circuits are used, speech transmission will take place in both directions. As regards the telegraph case, however, the second loop will be used for transmission in the opposite direction to the first loop.

A slight modification is required at a telephone repeater station where it is necessary to install a telegraph repeater. A " G " relay is used for this purpose and the conditions for reception are the same as those used at a terminal station. The local circuit, however, now becomes a transmitter and the conditions are similar to the transmitting end, and consequently it is necessary to insert a smoother before the re-energised telegraph signals are again impressed on the line. It is possible that before long the telegraph relay will be replaced by a thermionic repeater.

Fig. **5** shows a schematic lay-out of the system and will give some idea of the component parts of the circuit.

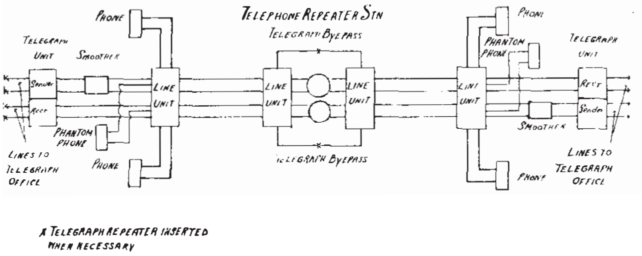


FIG. **5**.

The successful working of any system depends to a large extent upon the efficient maintenance of the apparatus. In this case the efficiency of the telegraph working will depend to a large extent upon the accurate regulation of the telegraph relays. In order to ensure as far as possible that relays are properly adjusted, a relay test panel has been designed. By means of this it will be possible to test relays for sensitivity, neutrality, and percentage of contact time. A speed measuring device is also associated with this unit in order to check the speed of vibrations of the receiving relays, which, as previously mentioned, are vibrating relays.

In conclusion, it may be of interest to quote the proposals as laid down by the C.C.I. with regard to composited working.

It should be noted that the C.C.I. Conference at present being held in Berlin has these proposals under review and it is possible that several alterations may be made.

In order not to prejudice the transmission quality of telephone circuits the following requirements must be met:—

1. The E.M.F. produced in the line circuit by the telegraph transmitter must not exceed 50 volts.

2. When the terminals of the telegraph transmitter are closed through a resistance of 30 ohms substituted for the line, the current through this resistance must not exceed 50 mA.

3. The increase in the attenuation of the telephone line due to composited telegraph installations must not exceed $b = 0.06$ or 0.5 TU for a line section having the length of the section between two successive repeaters, and over the frequency range of 300 c.p.s. and the maximum frequency transmitted.

4. Over 4-wire circuits the variation of line impedance produced by composited telegraphs must not exceed 10 per cent. in the frequency range indicated. As regards 2-wire circuits, composited telegraph installations must not exceed the values prescribed by the Telephone C.C.I. for the exact simulation of the impedance of the line by balancing networks.

5. Interference noise produced in telephone circuits by telegraph apparatus must not exceed a value which corresponds to an interference voltage of 0.1 mV for a transmission level $b = -1.0$ or -8.7 TU and an impedance of 800 ohms.

6. The increase in crosstalk produced by composited telegraph installations shall be determined as follows:—

> The cable quads are replaced by artificial lines free from crosstalk and reproducing, within the closest possible limits, the impedances of the circuits (terminal apparatus for quads). Under these conditions the attenuation corresponding to the crosstalk measured from the telephone office side must not be inferior to the following values:—
>
> (*a*) For 4-wire circuits: $b = 7.5$ or 65 TU for the crosstalk between any two speech circuits in the same quad.
>
> (*b*) For 2-wire circuits: $b = 8.5$ or 74 TU for the crosstalk between any two speech circuits in the same quad.
>
> (*c*) For 4-wire and 2-wire circuits: $b = 10.0$ or 87 TU for the crosstalk between two speech circuits in different quads.

7. For international telephone communications the total length of circuit sections employed simultaneously for composited telegraphy must not exceed 450 km. (approx. 280 miles).

8. After composited telegraph systems are connected into a circuit the unbalance to earth must not exceed the value prescribed by the C.C.I.

RURAL AUTOMATIC EXCHANGES.

NEW TYPE INTRODUCED BY BRITISH POST OFFICE.

A. Speight and J. C. Dallow.

INTRODUCTION.—(1) Several years ago the Department installed several "village" automatic exchanges. These were of different types in order that experience could be gained as to the feasibility of employing automatic plant in areas where only a limited amount of attention could be given. Several of these early exchanges are still providing a good service and the others have been converted to satellite exchanges.

(2) Apart from the few exchanges mentioned above, no serious attempt was made by the Department to introduce automatic working in rural areas until 1928 when consideration was given to the development of apparatus in "unit" form, thus catering for a small number of subscribers initially and allowing additional units to be added as required by subsequent growth.

(3) The main reasons for a reconsideration of the matter were as follows:—

(*a*) The increasing difficulty in obtaining caretaker operators for rural manual exchanges and the constant expense entailed in removing such exchanges to other premises because of the operating problem.

(*b*) The growing demand for a continuous service throughout the night as well as the day.

(*c*) The general introduction of automatic working at the larger exchanges, thus leading to the desirability of standardising automatic working for all sizes of exchanges.

(*d*) The great improvement in the design of automatic plant and consequent reduction of fault liability appeared to make it a more feasible proposition to leave automatic switches for considerable periods without attention.

(4) *R.A.X. Unit.*—This equipment is known as "Unit Auto No. 5" (see Fig. **1**) and has the following features:—

(*a*) The unit is in cabinet form, 6 ft. 3 ins. high × 2 ft. wide × 1 ft. 3 ins. deep, and is closed at the front and rear by sheet iron air-spaced doors closing on to felt. Each unit has capacity for 25 lines (subscribers and junctions) and a maximum of four units can be installed in one exchange. Junctions, as required, are provided to distant exchanges, the termination being on a manual board.

(*b*) The equipment is designed to function from secondary cells with a voltage range of 46 to 52 volts and a dial range of 7 to 14 I.P.S. Standard automatic telephones, with central battery talking, are fitted at the subscribers' premises.

(*c*) "Busy," "Ringing" and "N.U." tones are provided.

(*d*) Automatic metering on local calls.

(*e*) Coin box working and the provision of a distinctive coin box tone to the operator at parent exchange.

(*f*) Supervising signal on junction call, in either direction, controlled by the R.A.X. subscriber's switch-hook.

(*g*) Forced release is applied in 12 to 25 seconds to a selector held by a subscriber who has failed to dial or has dialled one digit only.

(*h*) In order to avoid waste of battery power in cases of permanent loop or equivalent conditions, the equipment is so arranged that after an interval of 15 to 30 seconds, the subscriber's calling equipment is cut off and the fault held on a high resistance relay. If the subscriber replaces the receiver, or in case of line trouble the fault disappears, the circuit is restored to normal working.

(*i*) No alarms are provided, but the operator at the parent exchange can, by dialling "99," ascertain the conditions at the R.A.X.

(i) Inverted ringing signal, when received, indicates that none of the faults, mentioned in ii. and iii., exists.

(ii) Receipt of "NU" tone indicates that a selector has failed to restore, a fuse has blown, or the charging set has stopped before charging has been completed.

(iii) If neither signal nor tone is re-

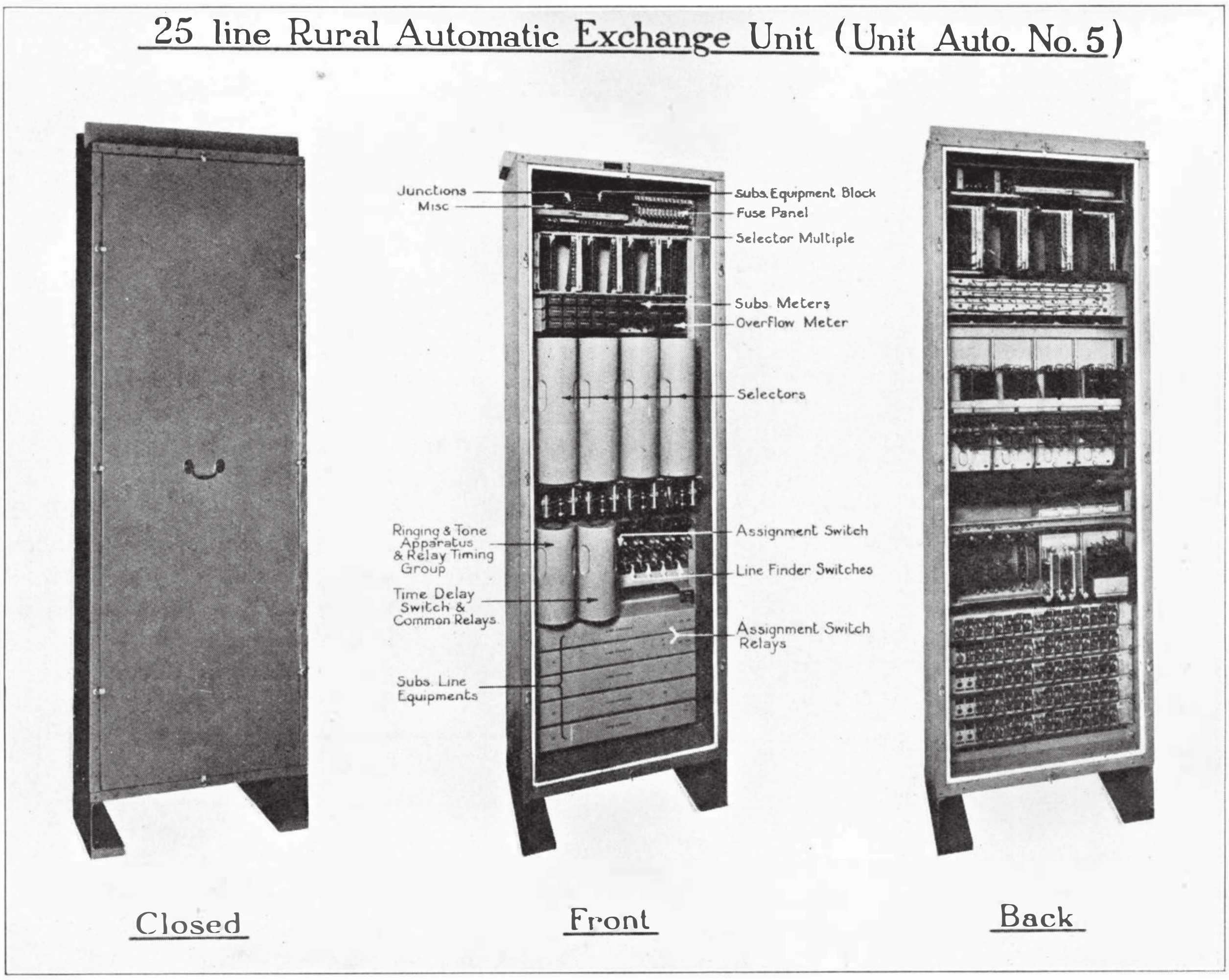


Fig. 1.

ceived the indication is that ringing has failed or the junction is out of order.

(5) Certain facilities, not considered to be essential, have not been catered for:

(*a*) Dialling tone.
(*b*) Party line working.
(*c*) Trunk barred facilities.
(*d*) Trunk offering and Operator hold.

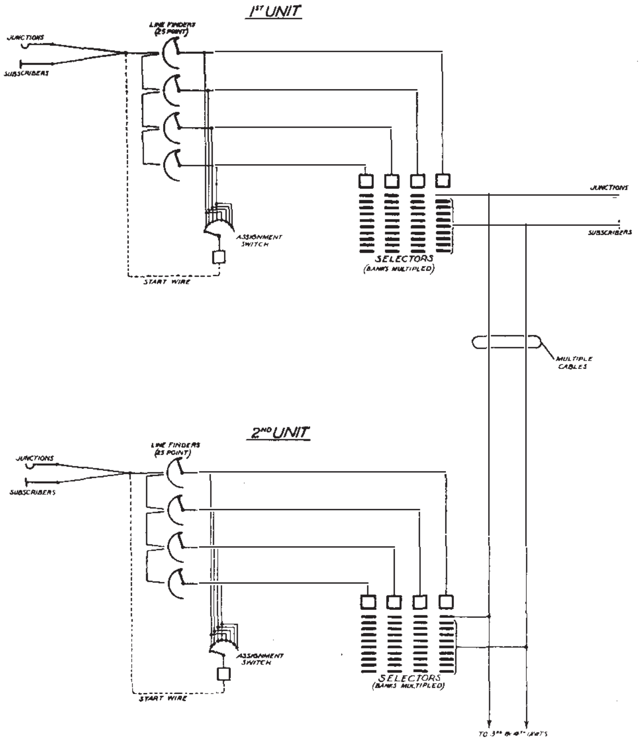


FIG. 2.

(6) The trunking scheme is shown in Fig. **2**. All calls, both junction and local, are effected by the dialling of two digits, the connections for both subscribers' and junction calls being made by means of " Connecting Links," four of which are fitted in each unit. Each " Connecting Link " consists of a Line Finder (a Non-homing Rotary Line Switch) associated with a 2-motion selector of the Strowger type.

An " Assignment Switch " allocates the connecting links in consecutive order as calls are originated. Normally the wipers of this switch are standing on the contacts of a disengaged connecting link and this link is seized by the next call. The assignment switch is then stepped to the next free link.

The subscribers' and junction lines are connected to the banks of the Line Finders and are also multipled on the banks of the Selectors. When a call is originated the Line Finder of the Connecting Link is brought into operation and its wipers are rotated until they reach the bank contacts associated with the calling line on which they stop. The selector of the Connecting Link is thus connected *via* the Line Finder to the calling line and receives the two trains of impulses from the caller's dial. The selector is stepped to the number dialled, ringing is automatically applied and cut off when the called party answers. Metering takes place on local calls when the called subscriber lifts the receiver.

All apparatus returns to normal when the calling party replaces the receiver.

(7) The numbering scheme is arranged so that levels 1 to 9 of the selectors are used for subscribers' lines. When an exchange consisting of one unit is opened, the subscribers' numbers commence on level 2 and continue as more units are added to level 9, level 1 being the last level to be brought into service.

Level 0 is reserved for junctions in all cases. Junctions to more than one exchange may be provided. If there is only one group of outgoing junctions the number to be dialled would be " 01." If there are two groups the second would be called by dialling, say, " 05."

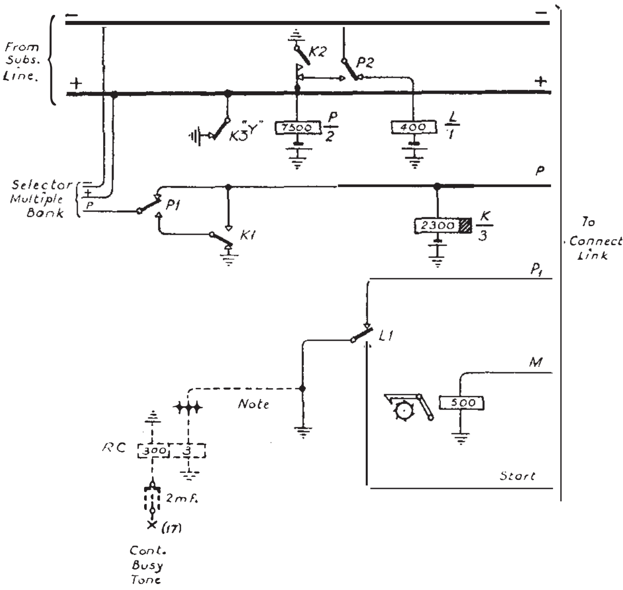


FIG. 3.

Note.—When a coin box line is connected to this circuit Earth is disconnected and dotted connections made.

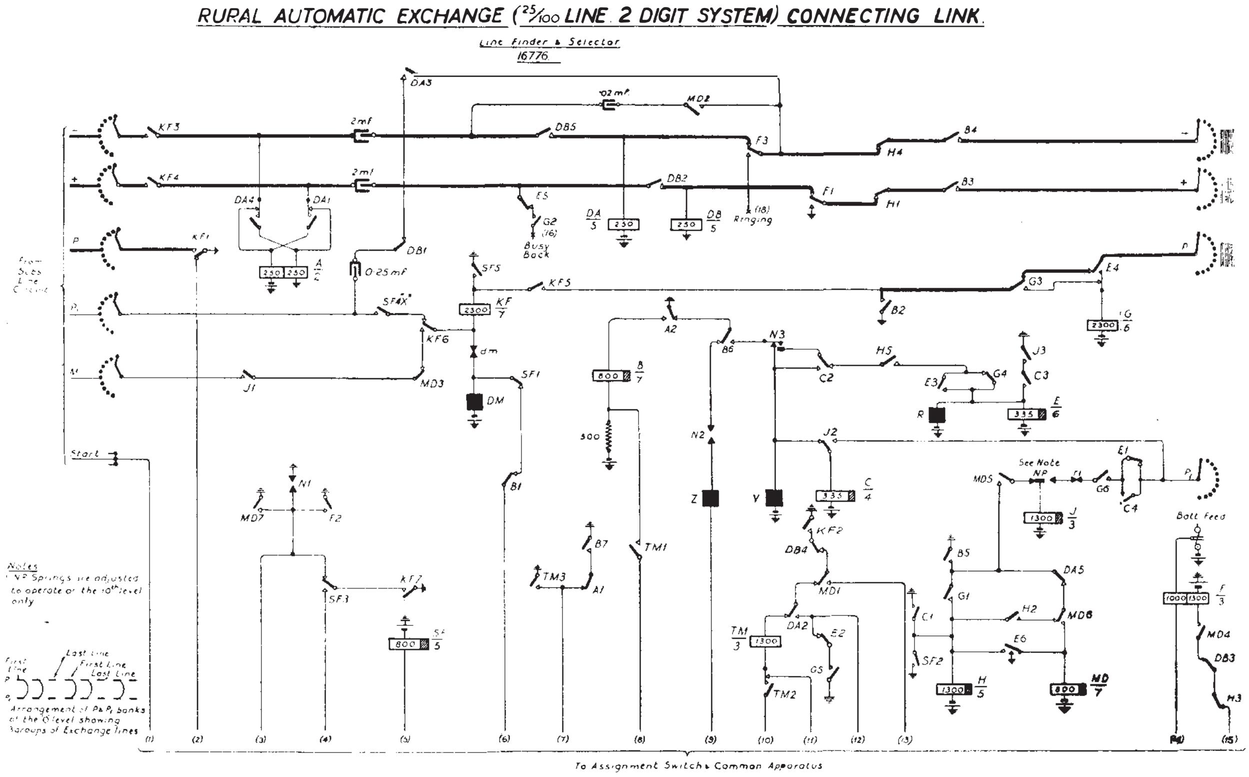

RURAL AUTOMATIC EXCHANGE (25/100 LINE 2 DIGIT SYSTEM) CONNECTING LINK.
Line Finder & Selector
16776
From Subs Line Circuit
Start
Notes
NP Springs are adjusted to operate on the 10th level only
First Line
Last Line
First Line
Last Line
Arrangement of P & P1 banks of the 0 level showing 3 groups of Exchange lines
Busy Back
Ringing
See Note NP
Batt Feed
To Assignment Switch & Common Apparatus

Fig. 4.

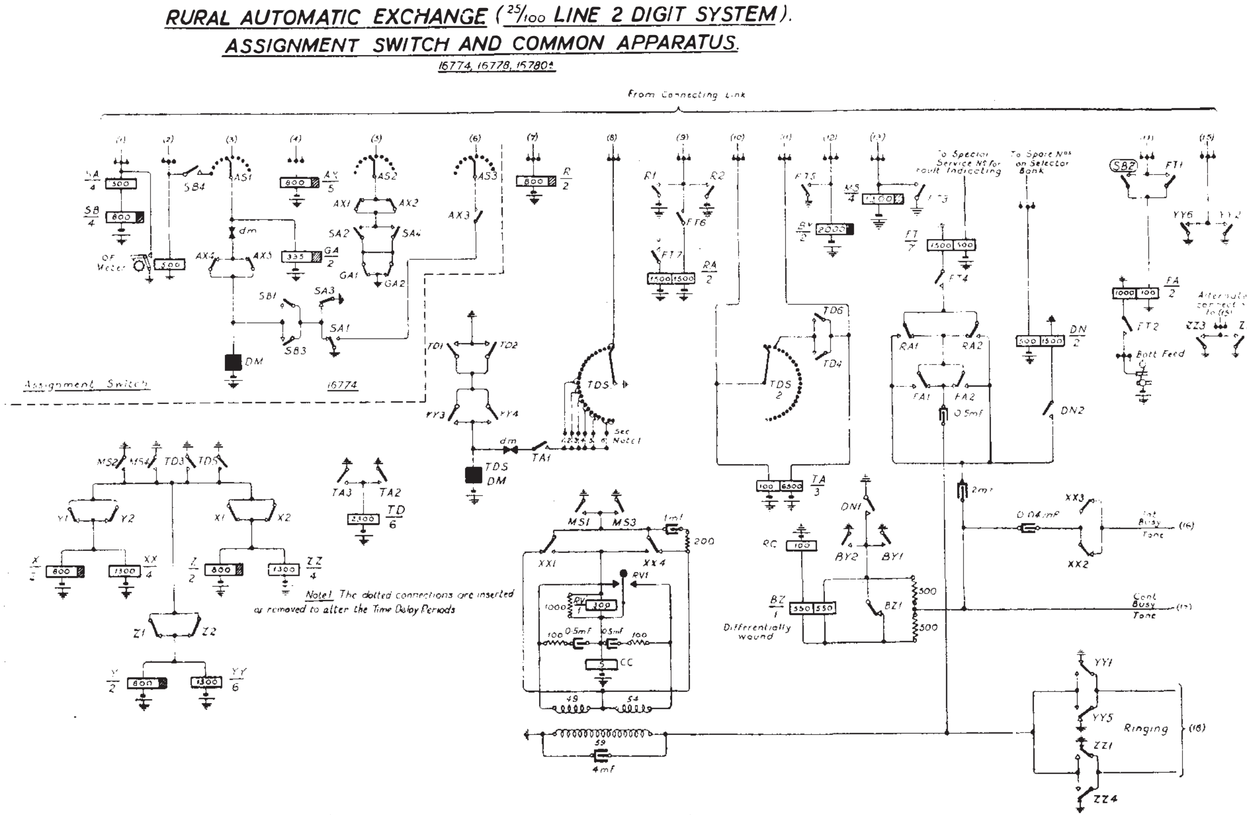
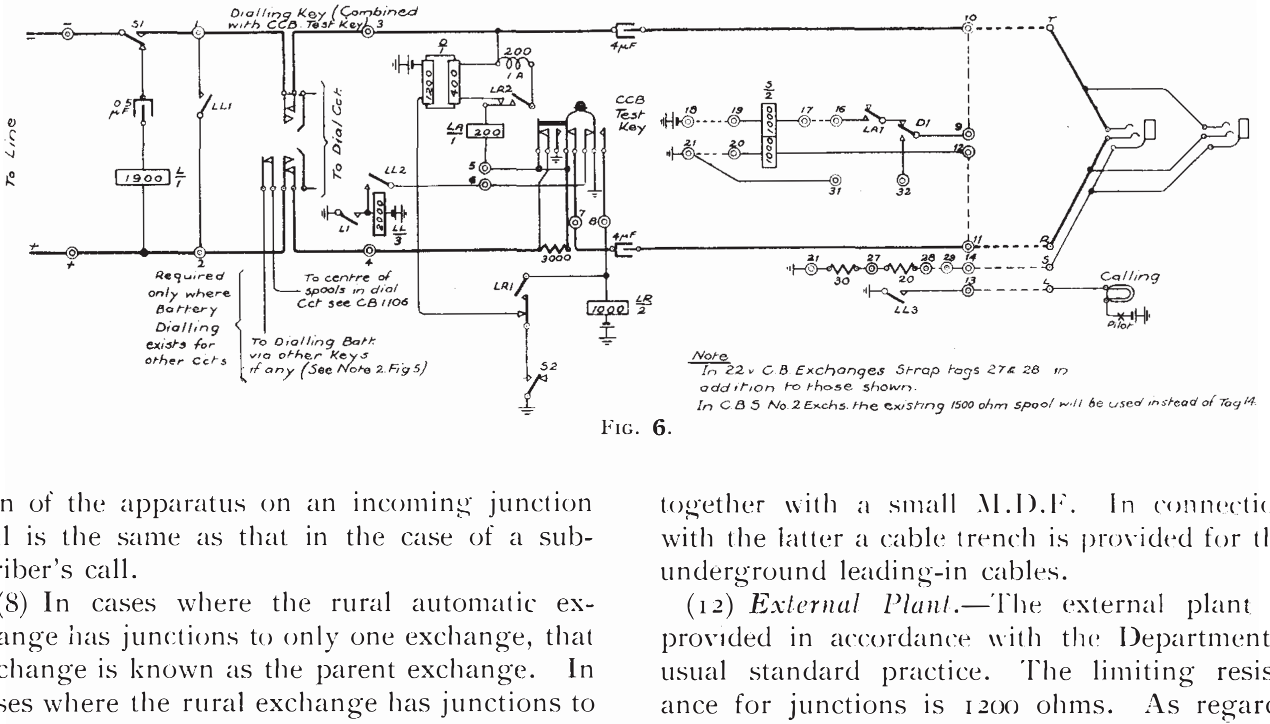

RURAL AUTOMATIC EXCHANGE (25/100 LINE 2 DIGIT SYSTEM).
ASSIGNMENT SWITCH AND COMMON APPARATUS.
16774, 16778, 16780s
From Connecting Link
Assignment Switch
16774
To Special Service Nos for Fault Indicating
To Spare Nos on Selector Bank
Alternate connection to (15)
Batt Feed
Note 1 The dotted connections are inserted or removed to alter the Time Delay Periods
See Note 1
Differentially wound
Int Busy Tone
Cont Busy Tone
Ringing

Fig. 5.

The total number of outgoing junction terminations cannot exceed ten. Since junctions to more than one exchange may be provided, several small groups of junctions may be accommodated, each group being terminated on a group of consecutive bank contacts. When the second digit of the junction number has been dialled an automatic stepping circuit is brought into use on the 0 level, causing the selector wipers to step on if the first junction to the required exchange is engaged. This automatic stepping continues as long as the selector wipers encounter busy junctions until the last line to the required exchange is reached. If this be engaged, busy tone is returned to the calling party.

Both junctions and subscribers are equipped with similar calling apparatus so that the operation of the apparatus on an incoming junction call is the same as that in the case of a subscriber's call.


To Line
Dialling Key (Combined with CCB Test Key)
S1
S2
0.5 μF
LL1
LL2
LL3
L1
1900 L/1
To Dial Cct
1200
400
200
1A
LR2
LA/1
200
2000
LL/3
CCB Test Key
3000
4μF
4μF
LR1
1000 LR/2
S/2
1000
1000
LA1
D1
30
20
Calling
Pilot
T
R
S
L
1
2
3
4
5
6
7
8
9
10
11
12
13
14
16
17
18
19
20
21
27
28
29
31
32
Required only where Battery Dialling exists for other Ccts
To centre of spools in dial Cct see CB 1106
To Dialling Batt via other Keys if any (See Note 2. Fig 5)

Note
In 22 v C.B. Exchanges Strap tags 27 & 28 in addition to those shown.
In C.B.S. No. 2 Exchs. the existing 1500 ohm spool will be used instead of Tag 14.

FIG. 6.

(8) In cases where the rural automatic exchange has junctions to only one exchange, that exchange is known as the parent exchange. In cases where the rural exchange has junctions to more than one exchange, the exchange which deals with the indirect junction and trunk traffic is termed the parent exchange.

Two rural automatic exchanges cannot work direct to each other, but one manual exchange may gain access to another *via* an intermediate rural auto exchange.

(9) Figs. **3**, **4** and **5** show the circuits of the automatic apparatus comprising the unit, and Fig. **6** gives a typical example of the auxiliary apparatus required to be installed in the junction termination on the manual board at the parent exchange. A brief description of the circuit operation is given as an appendix to this article.

(10) *Power Plant.* — A small power plant comprising two sets of 25 - 40 amp. hour secondary cells, a power board and means of charging is provided. When a public electric supply is available a Dynamotor or Tungar Rectifier is fitted, depending on whether the supply is direct or alternating current. If a public supply is not available a petrol-electric charging set is installed. In all cases the plant is so arranged that charging ceases automatically when a predetermined number of ampere hours has been put into the cells; attention during charging is therefore unnecessary.

(11) *Lay-out.*—A typical lay-out is given in Fig. **7**, which shows four 25-line units assembled, together with a small M.D.F. In connection with the latter a cable trench is provided for the underground leading-in cables.

(12) *External Plant.*—The external plant is provided in accordance with the Department's usual standard practice. The limiting resistance for junctions is 1200 ohms. As regards insulation resistance on both subscribers' and junction lines, it was appreciated that open wire construction would be concerned and therefore the automatic equipment was designed to allow an insulation resistance of 20,000 ohms on either line to earth or between the positive and negative lines. The high resistance relay which holds a line under P.L. conditions (see paragraph 4 *h*) does not retain until the insulation resistance decreases to about 9,000 ohms.

(13) *Building and Site.*—The whole of the ex-

change equipment for an ultimate of 100 lines is housed in a non-pretentious building (see Fig. **8**) having internal dimensions of 14 ft. × 7 ft. × 6 ft. 8 inches high. A site measuring 60 ft. × 20 ft. is specified in order to allow for future extension in cases of abnormal growth when an additional building unit would be erected, end-on to the existing one, and any necessary modifications to the plant carried out.

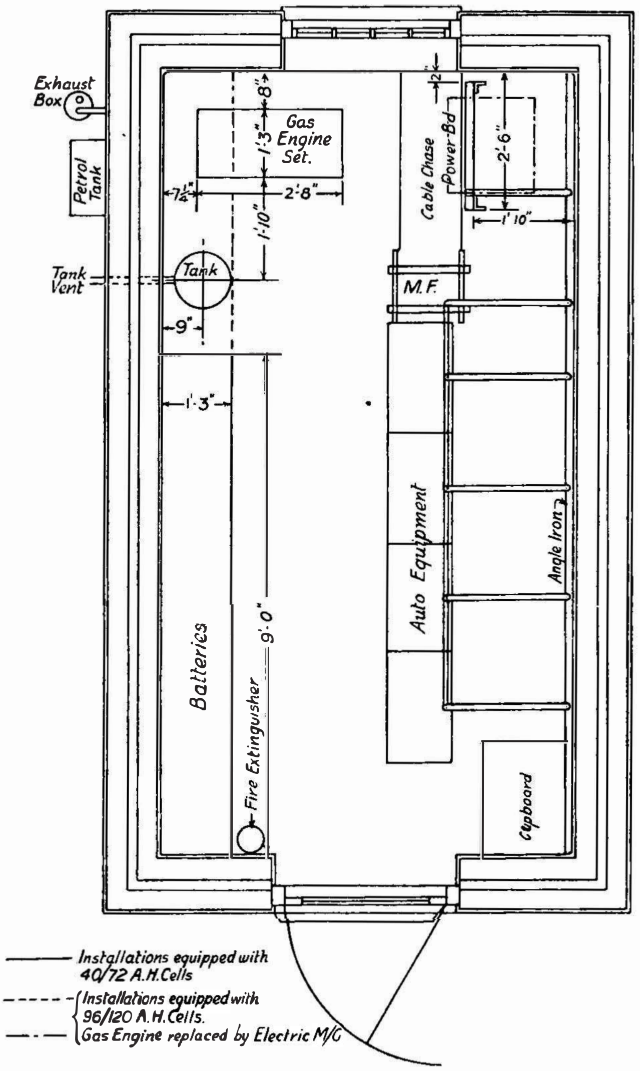


Fig. **7**.

The building is provided with hollow walls to prevent rapid changes of temperature and this, together with the feature of the sheet iron air-spaced doors fitted on the automatic unit, is intended to avoid the necessity for heating the building.

A call office kiosk containing a prepayment coin box will usually be erected on the exchange site, local calls being obtained in an automatic manner and junction calls *via* the parent exchange.

Opportunity is taken to make the exterior of the building and the site in keeping with the amenities of the locality by providing a modest garden, a privet hedge, climbing roses, a plot of grass, etc.

Conclusion. — The first of the new type of rural automatic exchange was opened at Haynes (Bedfordshire) on February 4th, 1929, and since then twenty additional exchanges have been opened. In spite of very severe conditions this winter and a temperature below freezing point being experienced in at least one of the exchanges, the apparatus has functioned satisfactorily and appears to be justifying expectations.

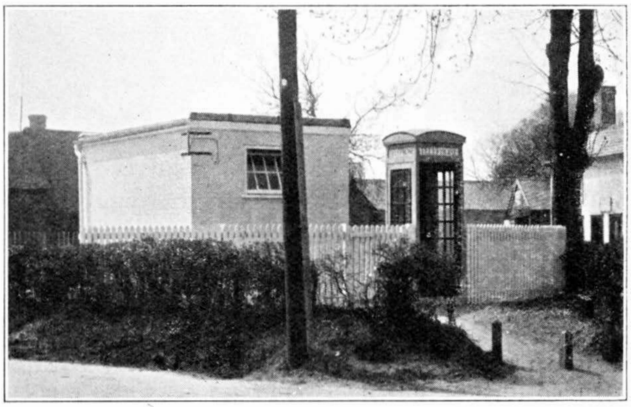


Fig. **8**.

It is the Department's intention to build rural automatic exchanges in areas where a minimum of eight subscribers are forthcoming, thus it can rightly be said that an effort is being made to provide telephone facilities in the sparsely populated country districts. It is hoped that the experiment will be a success and help in the education of the nation towards the acquisition of the "telephone habit."

APPENDIX.

CIRCUIT OPERATION.

Limitations of space will not permit a detailed account of the circuit operations. The following description indicates the functions and working of the chief items of the equipment for the various types of call which it is required to handle.

(1) *Local call—called subscriber free.*—When a subscriber removes the receiver, relay L (Fig. **3**) operates and earths the " start " wire of the assignment switch relays SA and SB (Fig. **5**). The SF relay of the connecting link (Fig. **4**) on which the switch is standing is operated *via* SA2 and connects the magnet of the line finder to the P1 wiper of the latter switch. All the P1 bank contacts except that of the calling line are earthed *via* the resting L1 contacts, so that the wipers are rotated (provided they are not on the calling line) and stop when the calling line is reached. The absence of earth on this P1 contact also allows relay KF to operate and the subscriber is switched to relay A. Earth *via* KF1 and the P bank contact busies the multiple contact and operates the subscriber's relays K and P, thus releasing relay L. KF2 starts the time delay switch (see paragraph 10).

Relay A operates, closing the circuit for relay B, and the subscriber dials the two digits required. The vertical and rotary stepping circuits operate in the usual manner, relay C being in parallel with the vertical magnet. Relay E, operated when the second digit is dialled, operates relay MD and holds relay H. MD1 removes the earth operating the time delay switch and closes the circuit of the ringing vibrator (see paragraph 7), MD 5 operates relay J, thus preparing the metering circuit. When the wipers reach the required line relay G tests, relay E releases and earth is extended to operate the called subscribers' K and P relays. Relay H releases, and connects the circuit of the 1300 ohm winding of relay F to the common apparatus *via* H3, and also extends the circuit of the required subscriber to F1 and F3. An intermittent earth then operates and releases relay F. Ringing current is applied on the " make " contact of F3 while the relay is operated, so that the wanted subscriber's bell is rung. During the released periods of relay F, relays DA and DB are extended to the called subscriber's line, these relays being operated in series during the next silent period after the called subscriber has removed the receiver. DB2 and 5 complete the speaking circuit between the two subscribers. DB3 disconnects relay F, so that it will not operate again. DB4 removes earth from the ringing apparatus.

DA1 and 4 reverse the lines to the calling subscriber (this facility is used for junction supervision only—see paragraph 5), DA5 breaks the circuit of relay MD, which releases after an interval. MD5 releases relay J, but as this relay is slow to release, a circuit is completed *via* MD3 and J1 to the calling subscriber's meter, which registers the call.

Assuming that both subscribers replace the receivers simultaneously relay A releases and completes the circuit *via* B7 and A1 of the release relay R (Fig. **5**). Relay B releases after a short interval, breaking the circuit of relay R and closing the circuit of the release magnet Z *via* R1 and B6. Relay R, being slugged, maintains the circuit of Z so that the magnet operates.

On release of the selector the earths holding the K relays of each subscriber are removed, and these relays, in releasing, extend the P relays to the subscribers' lines. The P relays are already operated and will lock if the line resistance is less than about 9000 ohms.

(2) *Local call—called subscriber busy.* — The operation of the apparatus is similar to that described above until relay G tests the required subscriber's line. G now operates *via* the P wiper, and on the release of relay E, locks *via* G3. The tone generating circuit is completed *via* G5 and E2 (see paragraph 8), busy tone being transmitted to the calling subscriber *via* G2 and E5. Relay H is held operated *via* G1, thus preventing connection of the negative and positive lines to the busy circuit.

Release is similar to that under " called subscriber free " conditions.

(3) *Spare number dialled.*—The positive selector bank contacts of spare circuits are strapped on the connection blocks and connected to relay DN, which operates in series with relay DB when a spare number is dialled. Continuous tone is then generated (see paragraph 8) and is transmitted to the calling subscriber *via* relay DN (which functions as an induction coil), positive bank contact, and the connecting link.

(4) *Outgoing junction call.*—Groups of junctions are accommodated on the " 0 " level. The P1 contacts on this level are wired to the connection blocks, and the P and P1 contacts of the first and intermediate lines in each group are strapped. The P1 contact of the last line of each group is left disconnected.

When a junction call is originated, the subscriber dials 0 and one other digit. The selector operates the normal post springs on the tenth step, thus changing over relay J, the metering relay, to become the rotary search relay. The second digit dialled causes the selector wipers to rotate to the first junction of the group, which is tested in the usual way by relay G. If disengaged, ringing current is transmitted in the same manner as for a local call. If the first junction is busy both P and P1 contacts will be earthed. Relay G operates and locks. Relay J operates *via* P1, completing the circuit of relay C. J3 and C3 close the circuit of the rotary magnet and relay E, and the wipers are stepped to the next contact. The rotary interrupter springs then open the circuit of relay J. The second junction is tested while relay E retains, and if busy, the same cycle of operations occurs, and continues until a free line or the last line of the group is reached. Since the P1 contact on the last line is disconnected the rotary stepping cannot continue and busy tone is transmitted when relay G operates.

On seizing a free junction, ringing current is transmitted to the distant exchange and chatters relay L (Fig. **6**). Relay LL operates and locks and the calling signal is given. Relay S operates on the insertion of the plug and the ringing is tripped by the short circuit at LL1. The operator next depresses the coin box key thus releasing LL, and operating LR. This key also earths the negative line of the junction *via* relay LA and the 200 ohms retard coil, and earths the positive line *via* a 3000 ohm spool. Under these conditions the operator hears continuous tone if the call is originated by a coin box subscriber (see paragraph 9). Absence of tone indicates that an ordinary subscriber is calling. When the key is released a dry loop is provided across the junction by the retard coil and relay LA and the circuit of the cord supervisory relay is completed *via* one winding of relay S and LA1. The operator then speaks to the calling subscriber and completes the connection.

When the calling subscriber replaces the receiver the selector releases, releasing the K relay associated with the junction. As K releases it extends relay P to the junction, which holds *via* LA and the retard coil. P holds and busies the selector bank contact, but LA releases and gives a clear to the operator. When the plug is removed P releases.

(5) *Incoming junction call.*—On plugging into the junction jack relay S operates, thus connecting LA and one winding of D across the junction, and completing the circuit of the other winding of D. D and LA operate and disconnect the cord supervisory relay, so that a clear is given. The operator throws the dial key, releasing both D and LA while the key is operated, and the clear continues. A connecting link at the R.A.X. is seized and the selector is stepped to the required number as the operator dials. Ringing is applied and when the called subscriber answers relay DA (in the connecting link) reverses the direction of the current in the junction. Relay D now releases while LA retains, so that the supervisory relay is connected and the clearing signal removed. When the called subscriber replaces the receiver the current in the junction is restored to the original direction and relay D re-operates, giving the clearing signal. On removing the plug S1 breaks the junction circuit and releases the connecting link.

(6) *Relay timing group.*—This is a group of six relays in the common apparatus which control the ringing vibrator and time delay switch, and provide the interruptions in the busy tone.

The three slugged relays X, Y and Z (Fig. **5**) are connected so that the circuit of each of them is dependent on the break contact of one of the other two. When a call is originated earth is extended *via* KF2 and relay TM (Fig. **4**) to operate relay TA in the common apparatus. TD is operated, and completes the circuit of all the relays simultaneously. Since it is practically impossible to obtain relays with exactly the same operating lag one of the three breaks its contacts first and the relays immediately commence operating and releasing in a cyclic order. The auxiliary relays XX, YY and ZZ operate with the control relays, each being operated in turn for approximately $\frac{1}{3}$ second.

(7) *Ringing.*—When a caller dials the second digit relay MS operates *via* MD1, retaining the circuit of the relay timing group, and closing the circuit of the vibrator magnet *via* XX1, these contacts operating and releasing as described in paragraph 6. The bob of the vibrator is attracted and held when the contacts are closed. When XX releases the bob vibrates mechanically between its two contacts, and an alternating current of about 16 cycles is generated by induction in the 59 ohm winding of the transformer in the ratio of $\frac{2}{3}$ sec. ringing $\frac{1}{3}$ sec. silence. Interruptions of $\frac{1}{3}$ sec. ringing $\frac{2}{3}$ sec. silence are supplied to the selectors *via* YY1 and ZZ1.

(8) *Tones.*—Continuous tones is generated by relay BZ. When its circuit is closed by BY1 or DN1 the relay operates and removes the short circuit from its second winding. This causes the relay to release, and thereby replaces the short circuit. These operations occur rapidly, and a tone of approximately standard pitch, *i.e.,* 400 periods per second, is generated.

Busy tone is provided by interrupting the continuous tone at XX2. Interruptions of $\frac{2}{3}$ second tone, $\frac{1}{3}$ second silence are given.

(9) *Coin box lines.*—The continuous tone is extended to one winding of the coil RC (Fig. **3**). The L1 contacts of coin box circuits, instead of being connected direct to earth, pass *via* the 3 ohm winding of the coil RC and then to earth. When a call is made to a distant manual exchange, the operator, on depression of the coin box test key earths the lines of the junction (paragraph 4) and releases relay DB (Fig. **4**). Tone is then induced in the coil RC and passes *via* L1, line finder, 0.25 m.f. condenser, DB1 and DA3, to the negative line of the junction and to the operator.

(10) *Time delay switch.*—When a call is originated KF2 extends earth and operates relay TA *via* its high resistance winding. Relay TM in the connecting link does not operate. TD is operated, the relay timing group is brought into use, and relay YY operates the magnet of the time delay switch once per second. The switch steps, and when the third bank contact is reached the two windings of relay TA are connected in parallel. The reduction in resistance allows TM in the link to operate. The switch continues stepping until the 12th contact, when the magnet circuit is completed *via* interrupter contacts. The wipers then rotate rapidly to the first contact where earth is now extended *via* TM1 to short circuit the " B " relay of the connecting link. The selector releases, removes the holding earth of relay K, which on release extends the P relay to the subscriber's line. The latter relay holds until the line is disconnected, and also busies the multiple contact.

The time delay switch is operated on every call, but it is cut out by MD1 when the second digit is dialled so that it is necessary to dial the two digits within a limited period. The switch is also brought into use under " called subscriber held " conditions.

It will be seen that any fault or subscriber's misoperation which causes a connecting link to be seized without giving two digit trains will result in the circuit being automatically switched over to the associated " P " relay and the common apparatus freed in less than 30 seconds. By the removal of the straps connecting the bank contacts the delay period may be varied approximately, between a minimum of 12 to 25 seconds and a maximum of 25 to 60 seconds.

(11) *Provision against breakdown.*—In an unattended automatic exchange it is especially important that all common apparatus shall be as fault proof as possible and that as far as practicable faulty circuits shall not be picked up. In order to attain the former condition all the more important relay contacts in the common apparatus are made of platinum and are duplicated. The latter condition is attained in certain cases as follows :—

(*a*) *Faulty lines.*—Any subscriber's or junction circuit which develops a loop or negative line earth is isolated and busied as described in paragraph 10. The high resistance of the P relays used for this purpose (7500 ohms) also minimises the current consumption so that the danger of battery failure when such faults occur is greatly reduced.

(*b*) *Blown link fuses.*—When a connecting link fuse blows the spring on the underneath side of it prepares the 1000 ohm winding of relay F (Fig. **4**). On relay SB being operated by a calling subscriber relay F operates *via* SB2, the link is busied on the assignment switch bank by earth extended *via* F2, and the faulty link is passed over.

(*c*) *Subscriber's line equipment fault.*—It has been found necessary to provide against a possible breakdown which could be caused by the L1 resting contacts of a subscriber's equipment becoming dirty and failing to maintain earth on the line finder banks.

Should this fault occur and another subscriber makes a call, the line finder of the link hunts and (if it does not encounter the caller's line first) stops on the faulty circuit. KF (Fig. **4**) operates and extends the circuit to the A relay, but as the faulty circuit is not calling, A does not operate. KF7 operates relay AX (Fig. **5**) *via* SF3. AX1 breaks the circuit of SF. When SF releases the circuit of AX is broken, but a circuit for the line finder magnet is completed *via* SF1, B1, assignment switch, AX3 and SA1 during the releasing period of AX. When AX releases the circuit of SF is again completed, and the normal hunting circuit re-established.

(12) *Testing from distant exchanges.*—In order that the " parent " exchange may verify that the R.A.X. apparatus is free from certain faults, the special testing facility is provided, as previously indicated. A " parent " exchange operator calls " 99 " at intervals during the day. The positive wiper of the selector completes the circuit of relay FT (Fig. **5**) which is connected to the positive bank contact of 99. FT operates and the ringing and tone apparatus is started.

Equipment OK.—If none of the undermentioned faults exists, the operator hears interrupted ringing tone in the ratio of $\frac{2}{3}$ second tone $\frac{1}{3}$ second silence transmitted *via* FA1, RA1, FT4 and relay FT, the relay functioning as an induction coil.

Ringing or relay timing group failure.—The tone is absent or irregular according to the fault.

Blown fuse.—Should a fuse be blown relay FA operates *via* a fuse alarm bar, relay F, FT1 and the 100 ohm winding of relay FA, or alternatively *via* FT2 and the 1000 ohm winding of relay FA. FA1 connects N.U. tone to relay FT and the tone is transmitted to the operator.

Switch release failure.—In this case the off normal springs of the selector are closed, so that the closure of FT6 causes relay RA to operate. RA1 again causes N.U. tone to be sent out.

Charging plant failure.—Should the charging plant fail before being automatically stopped by the ampere hour meter on the power panel, FT7 will be earthed and on the operation of FT the circuit of RA is completed and N.U. tone is again transmitted.

LLANDUDNO AUTOMATIC EXCHANGE FIRE.

A. Speight.

On February 26th, 1929, late in the evening, a fire broke out in the Head Post Office building. In this building, a three-storey one, is conducted the postal and telegraph work, and the automatic telephone exchange, 1,200 lines equipped capacity, is housed on the second floor. The fire appeared to originate in a stores room on the third floor, above a portion of the automatic exchange, and before the outbreak was got under control a portion of the roof collapsed, and also some of the third storey flooring was burnt out. Blazing material thus fell on to the automatic apparatus, resulting in the complete destruction of the main cable run to the Main Distributing Frame, the meter cables, power cables, and also the switches on the upper shelves of the 1st preselector racks. The remainder of the auto apparatus not actually burnt or damaged was flooded with water. There was a severe frost at the time and the water froze, with the result that the building and adjacent roadway were thickly coated with ice.

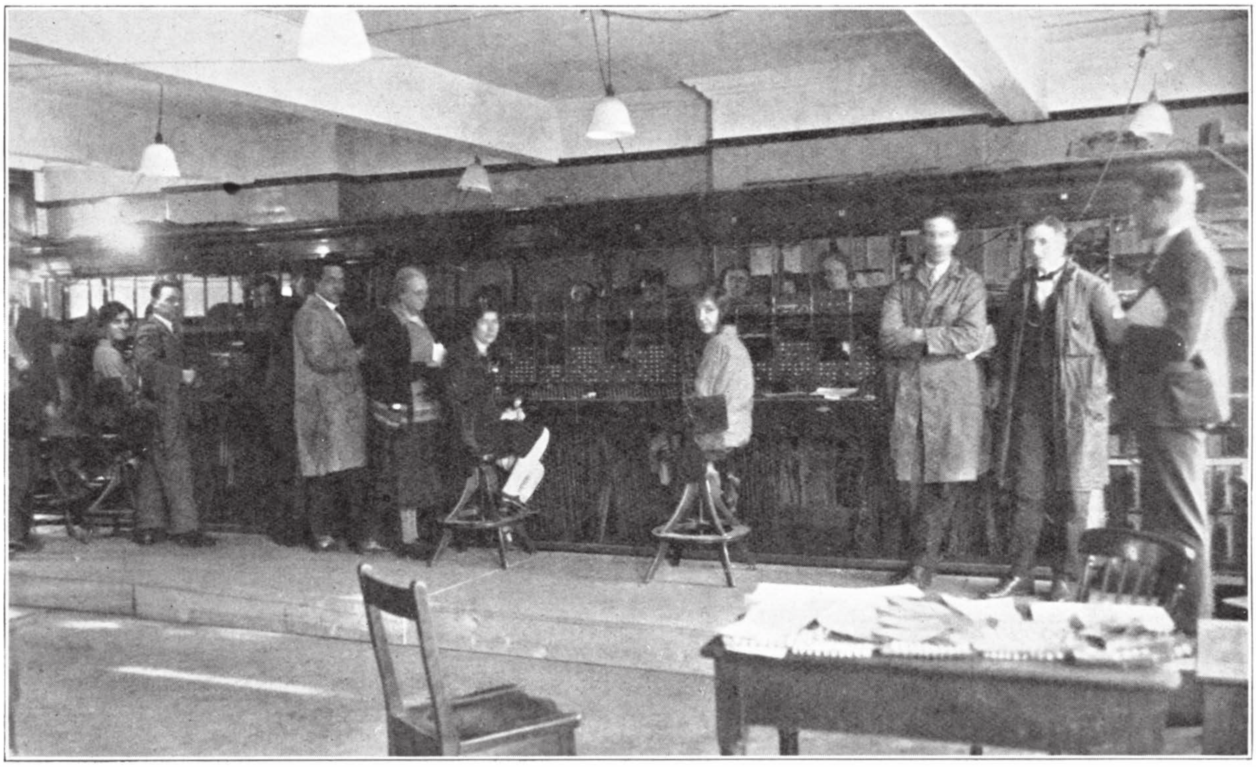


Fig. 1.—Emergency Manual Switchboard, showing state of reconstruction on 4th March, 1929.

A survey was made of the automatic exchange and it was a great relief to find that the power plant and M.D.F. were intact, although the latter had suffered from water. A decision was soon arrived at that it was impossible to restore the automatic equipment within a reasonable time and therefore it was necessary to revert temporarily to C.B. manual working.

Llandudno is part of a multi-office area with the auto-manual switchboard located at Colwyn Bay. Penrhynside is a satellite on Llandudno for originating calls other than local and O level. Fortunately there were a considerable number of spare circuits in the underground cables between Llandudno and Colwyn Bay, also between Penrhynside and Colwyn Bay; it was thus possible to restore service to all Penrhynside subscribers and to Llandudno call offices and important subscribers by connecting them direct to Colwyn Bay.

Meanwhile, a 1200-line fire emergency switchboard, capable of meeting various circuit conditions, was on its way from the Birmingham Stores Deparment. It was decided to clear the telegraph instrument room and install four 3-position "A" sections, one 3-position "B" section and one single position dummy section in the room thus vacated, and by 7.0 a.m. on February 28th (36 hours) all the sections were lined up in position. The fire emergency equipment comprised approximately 80 packing cases, many very large, and the writer will never forget the circumstances under which these had to be handled in darkness from the railway depot (the conditions of snow and frost on the roads were too bad for motor transport from Birmingham), unpacked in the roadway in the intense cold and the equipment carried up a comparatively narrow staircase. The M.D.F. was dried out, counter E.M.F. cells to reduce the voltage from 60 to 22 volts were installed, and as a result of much hard work and little sleep the sections were wired, a fuse panel and cord circuit special apparatus rack fitted, cabling to the old M.D.F. provided and a portion of the manual emergency switchboard brought into service at 12.30 p.m. on March 4th (134 hours). The work was pressed forward and all the subscribers reconnected by March 6th, or 6 days after the fire.

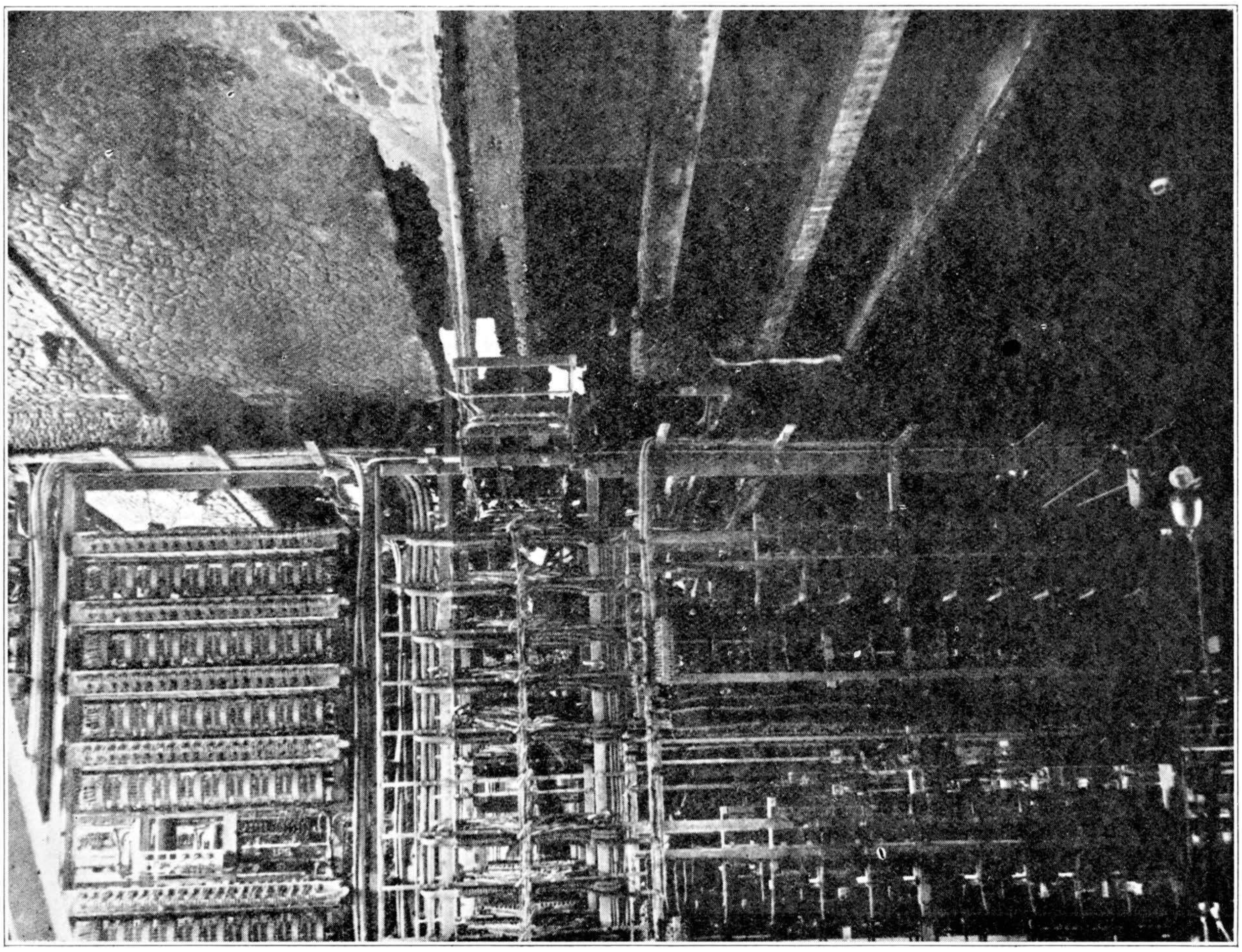


Fig. 2.—Damaged Ceiling. Daylight showing through destroyed roof.

While the installation of the emergency switchboard was proceeding, the automatic plant was receiving attention, as it was realised that unless the matter was dealt with at once rusting and corrosion would be so widespread that none of the plant could be used again. Every effort was therefore made to save as much of the apparatus as possible. All the selectors, relay sets, bank shelves, etc., were removed from the racks, given a preliminary cleaning and set aside on wooden shelving in a hot room to dry. Apparatus which could not be removed conveniently was dried out in position by means of a large number of hairdressers' electric hair driers disposed about the racks. That this policy was to be successful was demonstrated when after three days several dried-out relay sets were tried at Colwyn Bay automatic exchange and found to function perfectly, their insulation being infinity on test.

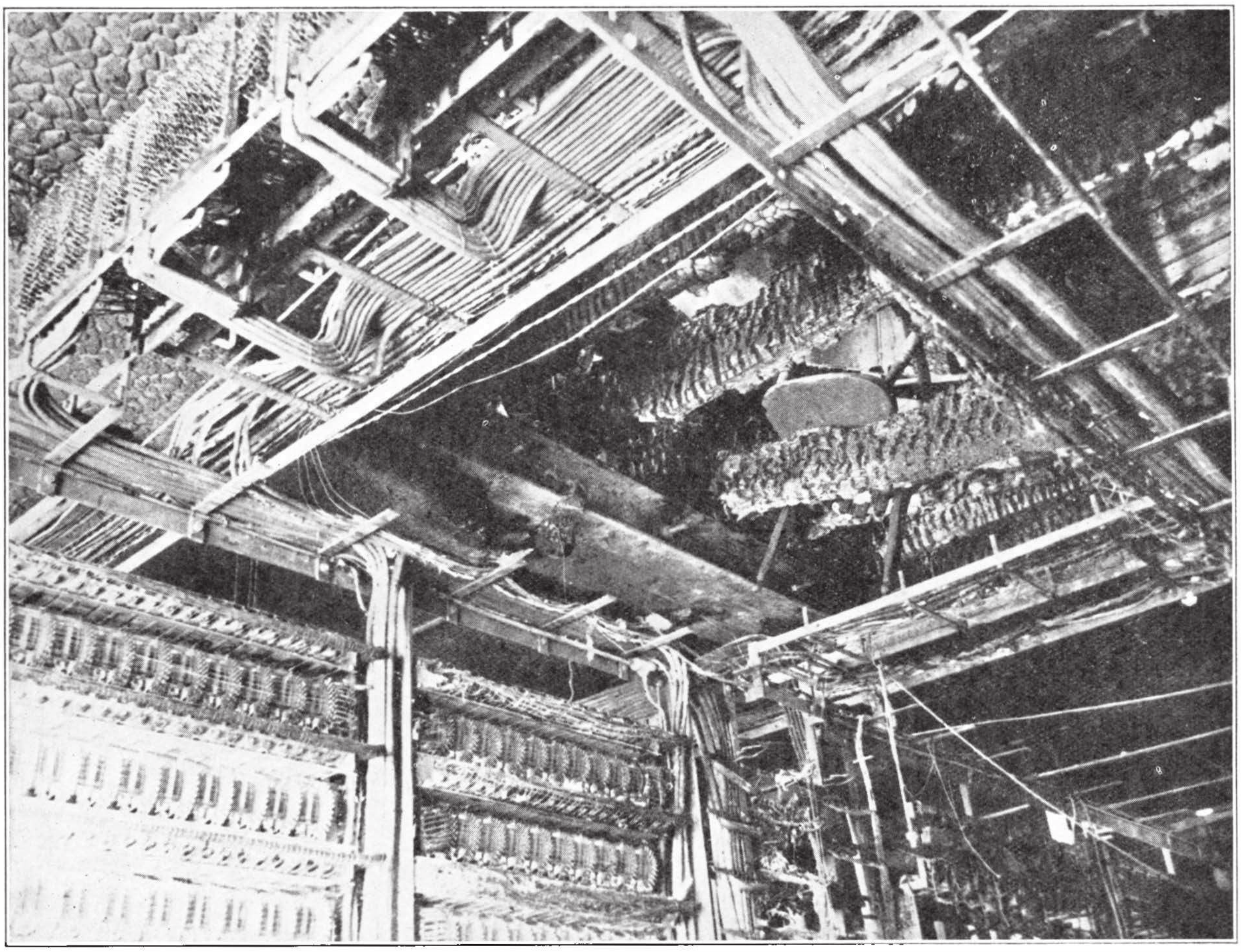


Fig. 3.—Burned out Ceiling, Automatic Apparatus Room.
Note the destruction of main cable run and section I.D.F.

Messrs. Siemens Bros., the makers of the equipment, were entrusted with the work of reconditioning the exchange and commenced operations within a week of the fire. The " drying out " scheme was so successful that the whole of the switching plant not damaged beyond repair was brought into use again, and therefore the restoration resolved itself into reassembly and adjustment of the apparatus, plus new cabling. The Contractors rose to the occasion magnificently and, thanks to their efforts, the automatic plant was cut into service again with complete success on May 11th, or 10½ weeks after the fire.

The speed with which service was restored after the fire is thought to be a very satisfactory performance, and the Engineering Department is indebted to the Traffic and Stores Departments for the cordial co-operation so freely given.

AUTOMATIC ROUTINE TESTERS FOR AUTOMATIC TELEPHONE EXCHANGES.

PART II.

IN the previous article on this subject in the April issue, a general outline of the functions and operating procedure common to most automatic routiners was given. It is now proposed to describe features of particular interest in the Director and Coder Call Indicator (C.C.I.) Relay Set Routiner circuits.*

Director Routiner. — This routiner is so arranged that three types of tests may be made, viz.: "General Routine," "Continuous Routine" and "Group Routine."

The two former types are also made in the First Code Selector Routiner, certain features of which were mentioned in Part I. of this volume. The last type of test divides the Directors into groups corresponding to the levels of the "A" Digit Selectors in order that tests may be made of translations which are common to a particular group only. Fig. 1 shows the allocation of these groups on the "A" Digit Selector shelves. To commence this last type of test, the required code and digit keys, or code keys only, are thrown, together with the cancel keys of codes and digits not required. The "Group" key is then thrown and afterwards the start key. The primary distributor hunts for the group to be tested and then commences the tests. The hunting circuit is shown in Fig. 2. When the Start Key is thrown, relay HO operates and introduces the split-impulse guard relay GA; pulses are then delivered to the Primary Distributor DM. Relay GT will operate when the Primary Distributor reaches the contact, associated with the operated Group Key and will prevent further stepping.

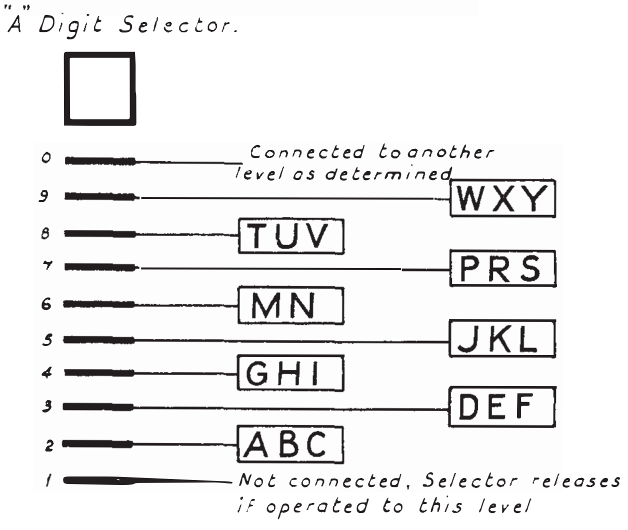

"A" Digit Selector.
0
9
8
7
6
5
4
3
2
1
Connected to another level as determined
WXY
TUV
PRS
MN
JKL
GHI
DEF
ABC
Not connected, Selector releases if operated to this level

FIG. 1.

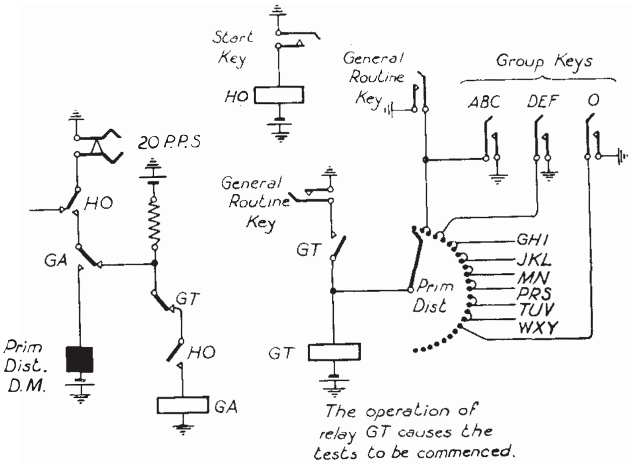


FIG. 2.

The access points required in connection with this routiner are P, +, −, PU and in some equipments M. The M connection is the Director meter switch jack point.

In the first few exchanges to be brought into use a "Busying Ahead" feature was incorporated in order that the next Director to be tested was busied as soon as it became free, while tests were in progress on the previous Director. This feature has, however, been omitted from later routiners on account of the reduction in availability of "A" digit selector outlets which it entailed and of the short holding time of Directors.

On operation of the Start Key under "General

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* *Typical Director circuits are shown in diagrams E 228, E 266 and E 247. C.C.I. Relay Set circuits in diagrams E 160, E 263, E 444 and AT 1956.*

Routine " conditions the Primary Distributor is stepped off-normal and the routiner is thereby connected to the first Director position of the " ABC " group. The routiner now applies a test to determine that the position is equipped and then tests the private for the engaged (earthed) condition. Should the Director be engaged for a period exceeding 30-60 secs. an alarm is given.

In some exchanges this is followed by a test for 400 ohms-battery, which is the only condition under which these Directors should normally be seized.

When the Director is disengaged, it is seized in the normal way by connecting a relay to the pulse lead, and the private is then tested to ascertain that it is guarded. The necessary delay period for making this test is provided by means of a slow relay. This test precedes all the main tests made by the routiner.

The routiner now waits for the " Forced Release " condition, which should occur within 30-60 secs. after seizure of the Director, and is tested by the relay connected to the pulse lead. Should " Forced Release " not occur within 90-180 secs. an alarm is given.

If earth is not removed from the private within a given time after the Director is released from the routiner at the end of each of the main tests, an alarm operates.

Some Directors receive impulses repeated from the First Code Selectors, and others impulses from the subscriber's dial, and it will be readily realised that these impulses may be distorted due to variation of dial speed and line conditions. To prove that the Director will respond to impulses within certain specified limits, two impulsing tests are made by the routiner, viz.: " Series " and " Shunt." Difficulty has been experienced in providing correct ratio impulses at constant speeds of 7 and 14 i.p.s. Hence the amount of impulse distortion caused by the worst permissible limits was measured in the Circuit Laboratory and values of series and shunt resistances, which when included in a 10 i.p.s. impulsing loop would produce the same amount of distortion, were determined. 10 i.p.s. impulses are now used for all impulsing tests, with series and shunt resistances added to simulate 7 and 14 i.p.s. respectively, as shown in Fig. **3**.

The " Series " test is made first. Two digits, representing the " B " and " C " digits, are sent to the Director, while the sending of the numerical digits is delayed until the first translated digit is received by the routiner. Condenser impulsing is employed in some exchanges for sending the digits. This method of impulsing ensures the same ratio of break-to-make in each impulse, irrespective of the normal variation in speed of the impulse machine. A voltmeter with a suitably damped action is fitted on the routiner and can be connected in the impulsing circuit by the operation of a key. When so connected it indicates the mean voltage of the circuit during impulsing. The ratio of the indicated voltage to the battery voltage gives the percentage " make " period of each impulse.

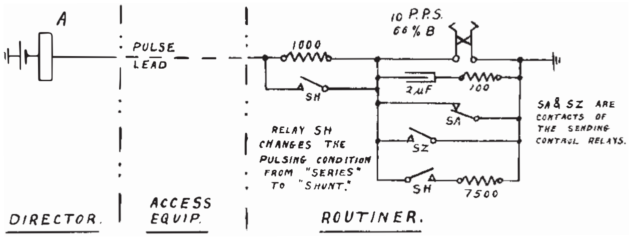

A
PULSE LEAD
1000
10 P.P.S. 66 % B
2 μF
100
SH
SA
SZ
SH
7500
SA & SZ ARE CONTACTS OF THE SENDING CONTROL RELAYS.
RELAY SH CHANGES THE PULSING CONDITION FROM "SERIES" TO "SHUNT."
DIRECTOR.
ACCESS EQUIP.
ROUTINER.

FIG. **3**.

The pause between the reception of the first and second translated digits is measured by means of a rotary switch, stepping at 20 i.p.s. Fig. **4** shows the connections of this switch.

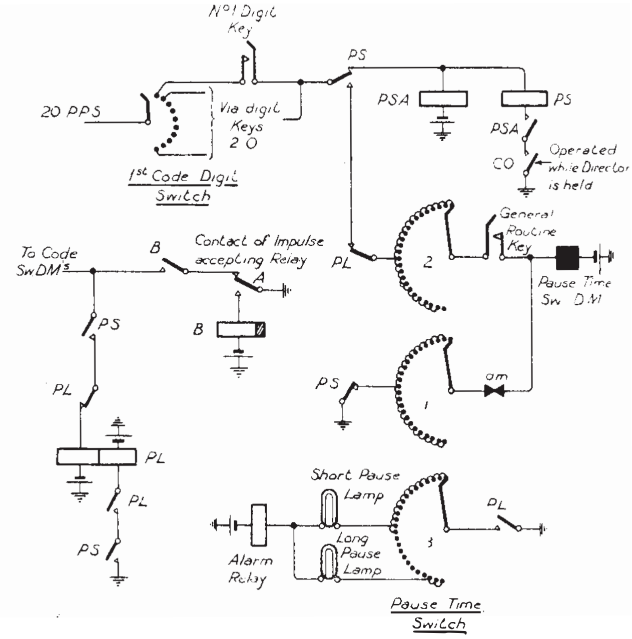


FIG. **4**.

When the " First Code Digit Switch " arrives at the contact associated with the digit sent, relays PSA and PS operate and direct the 20 i.p.s. to the Pause Time Switch DM, which continues stepping until the A contact again releases, when PL operates and causes the relevant lamp to glow should the pause be incorrect. The alarm is operated by the relay in series with the lamp. After the second digit has been received, the impulsing loop is reversed for a given period. In some exchanges the Pause Time Switch is used to measure this delay period. When this condition is applied the Director D relay should operate and prevent further digits being sent. The " Pause Time " and " Loop Reversed " tests are not made during " Group Routine " tests.

In most equipments the digits received by the routiner are distributed to each successive digit switch by means of a Digit Distributor, while in other equipments they are switched through by means of " two-step " relays. In the former case the digits are displayed together, and in the latter as they are received. The duration of the display is for 3-6 secs. Fig. 5 shows the connections of the Digit Keys and Display Lamps. As the Control Switch steps, earth is connected to each group of digit keys in turn and allows the digit to be sent as determined by the key which is thrown. The Digit Switches respond to the impulses received and the relevant display lamp glows. Relay WN operates the alarm should there be a discrepancy between the digit received and that sent, as determined by the key operated. The correct release of the Director is proved by the satisfactory operation under the subsequent tests.

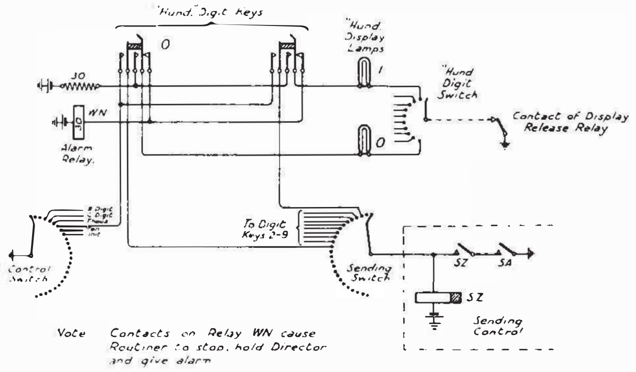


FIG. 5.

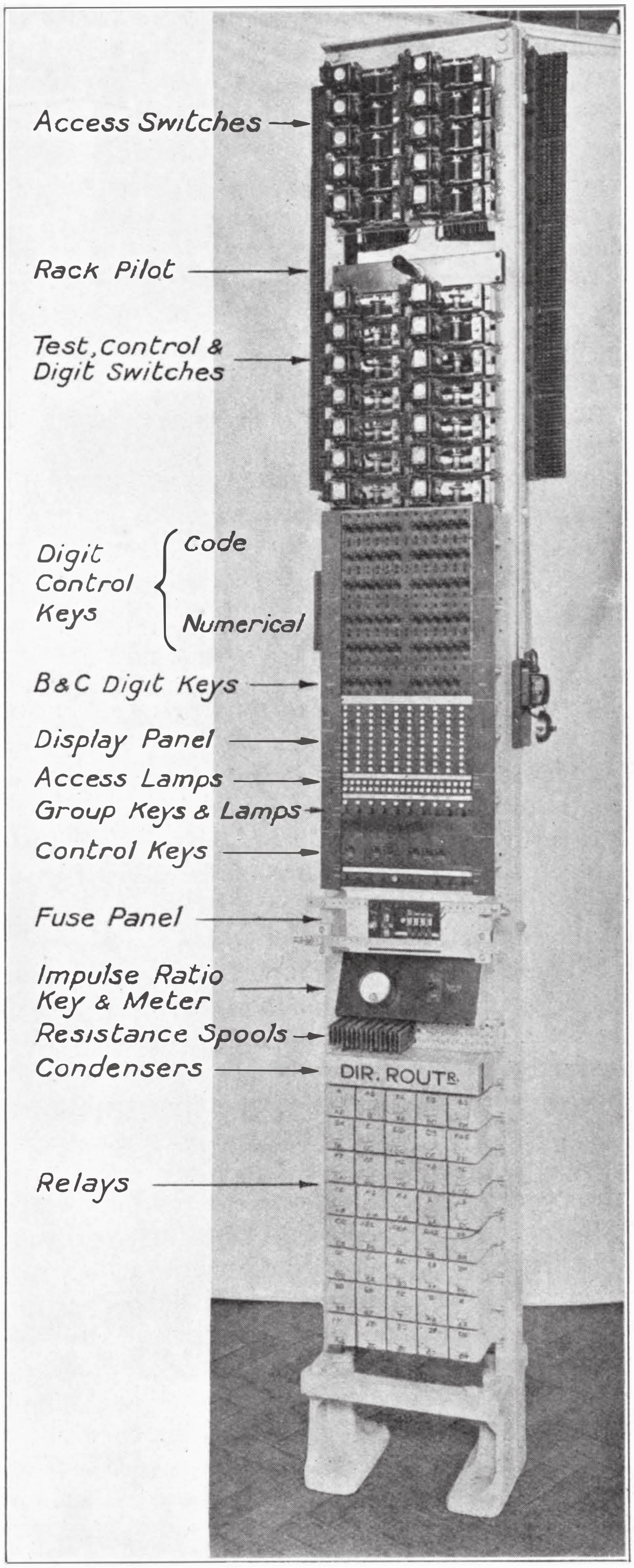


FIG. 6.—DIRECTOR ROUTINER.

The " Shunt " test, which follows, repeats all the functions of the " Series " test with the resistance in the pulse lead changed as previously mentioned.

Three main tests are therefore applied to each Director by the routiner, viz.:—" Forced Release," " Series Impulsing " and " Shunt Impulsing." Test cancel keys are provided in order that either or two of the tests may be cancelled.

During " General " and " Group " routine tests, when each Director has been satisfactorily tested, the Access Switch is stepped to the next position and the testing equipment restored to normal.

The timing of the release of the Director is now considered to be unnecessary and hence it has only been included in one or two of the early exchanges.

Certain Directors associated with the last choices of each of the " A " Digit Selector levels are also connected to the " O " level of this selector, for the purpose of routing Assistance Calls to the Manual Board. These Directors are connected to an Access Switch serving only " O " Level Directors, as well as to the one associated with other Directors on the same selector levels. When tests are made *via* this Access Switch the routiner connections are automatically changed in order to test the " ' O ' Level " feature. The routiner seizes each of the Directors with the − and + leads reversed and the Director should immediately send out the necessary digits for routing to the Manual Board.

A meter is connected to the routiner in such a manner that it records each time a Director meter is operated due to routine testing. The " M " (meter) access point is used for this purpose in later exchanges.

The routiner provides individual lamp indication of the particular Director being tested.

Fig. **6** shows the lay-out of apparatus on a typical Director Routiner rack.

C.C.I. Relay Set Routiner. — The C.C.I. equipment at the manual exchange end of " Auto-manual " junctions is so arranged that any calling condition applied to the junction will be passed through to an operator's position, and the junction held until it is released by an operator. It will, therefore, be appreciated that, when routine testing or making adjustments to the C.C.I. Relay Sets at the Automatic Exchange terminations of such junctions, it is necessary to avoid applying any conditions which are likely to produce false calling signals. To accomplish this, a relay is added to each C.C.I. relay set in the manner shown in Fig. **7** and the inset to Fig. **9** in order to keep the junction disconnected when such operations are in progress.

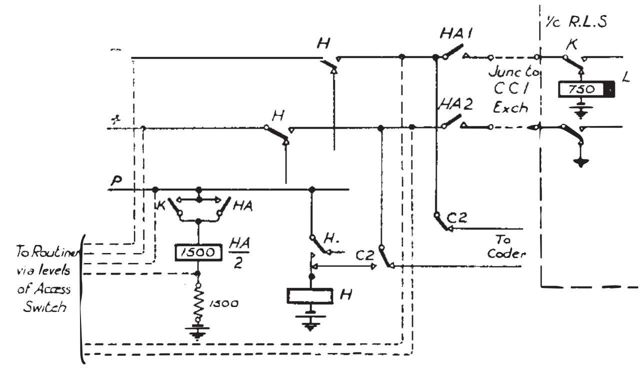


FIG. 7.

The relay designated " HA " is connected to the private wire and is operated therefrom when the relay set is seized under normal conditions, but its connections are such that it can be short-circuited by the routiner when required.

Routiner access for C.C.I. Relay Sets is arranged by means of " Primary Distributors " and " Access Switches " as described previously, the former being mounted on the routiner rack, whilst the latter are fitted on the apparatus racks. The numbers of C.C.I. Relay Sets in general warrant more than one " Primary Distributor " and the scheme as employed for 1st Code Selectors is also used in this case.

The number of access points on " C.C.I. Relay Sets " is such that two switches are required for each " Primary Distributor " stage and it is necessary that these two switches shall be synchronized. Stepping is therefore controlled as shown in Fig. **8**; the drive magnet of the first switch being stepped by the normal routiner stepping circuit and the auxiliary switch then stepping by self-interrupted drive due to the " slipped " multiple between the arcs as shown.

A test switch is fitted for applying the sequence of tests and changing the testing conditions.

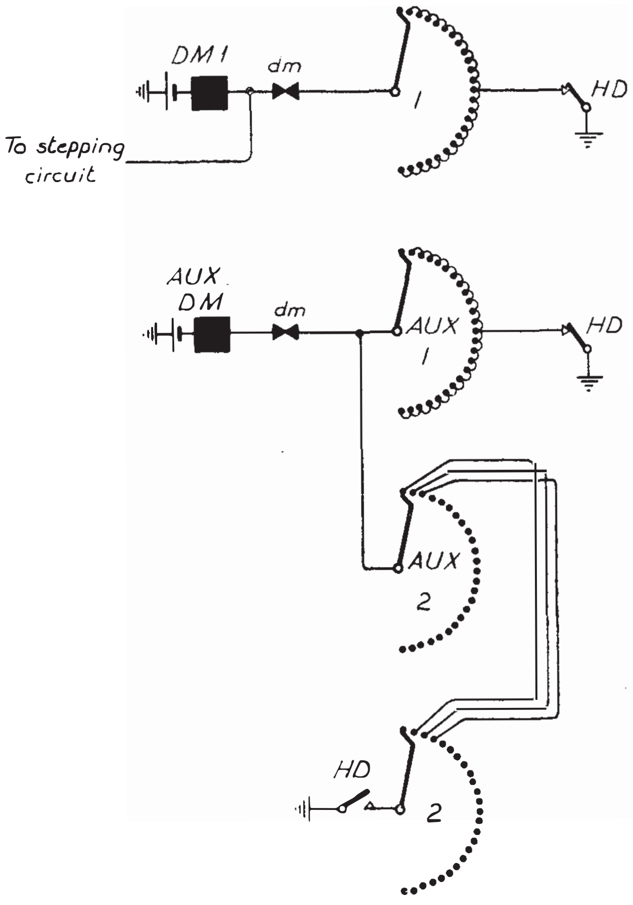


FIG. 8.

On operation of the " Start " key, the routiner tests the " Primary Distributor " outlet to ascertain whether it has an " Access Switch " connected to it. This is termed the " Unequipped " test and if the outlet is unequipped the " Primary Distributor " is stepped until an equipped outlet is found. The associated access switch is then stepped in a similar manner.

Fig. **9** gives a typical illustration of the circuit used for this test. Relay KA is connected to the HA relay access point, which is earthed in the case of unequipped positions, giving a circuit for relay KA which releases relay DB, thereby allowing a further step of the access switch.

When an equipped outlet is found, the private of the associated relay set is tested for busy condition. Again referring to Fig. **9** relay TC operates and energises relay PE; contact PE1 closes a circuit for its second winding to the private of the Relay Set. While the latter is busy, relay PE will hold and prevent the test switch from stepping. If it is still busy after a period of 3-6 minutes, an alarm will be given.

When the Relay Set becomes disengaged, the routiner earths the private, steps the Test Switch and applies a simple test to check the presence of battery and earth on the respective lines of the junction to the C.C.I. exchange. This test is made by means of high resistance relays in the routiner, which are connected to the − and + junction lines in turn. The current required for operating these relays is insufficient to operate the line relay at the C.C.I. exchange.

The " HA " relay is now short-circuited to prevent interference with the junction during subsequent tests. In the standard case, the release of this relay is checked before proceeding with the tests, by noting the disconnection of earth from the + line.

The operating adjustment of the " A " relay is tested next. A loop of such resistance that a current equal to the specified " Non-operate " current of the relay flowing *via* a " Shunt Field " relay is applied for a given period. Should the " A " relay operate under this condition, the associated coder finder will hunt to find a free coder and when the latter has been found the battery on the incoming lines to the relay set will be reversed, thereby releasing the shunt field relay, causing the routiner to be stopped and an alarm to be given.

Fig. **10***a* shows this circuit. Relay TF operates with the application of the loop when

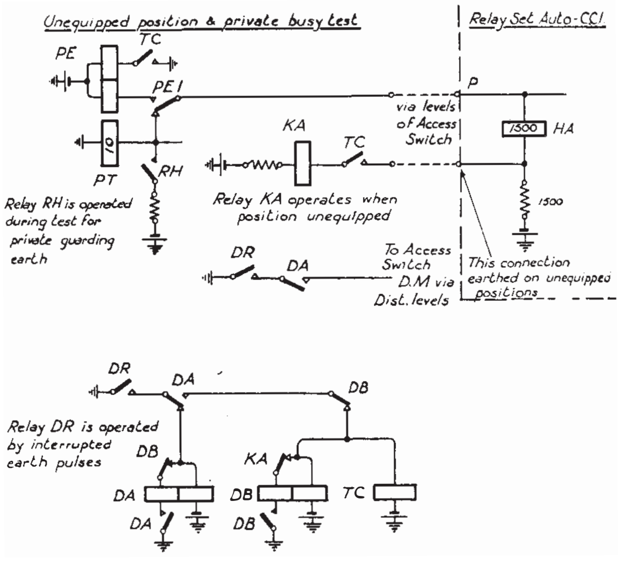

Unequipped position & private busy test
Relay Set Auto-CCI
TC
PE
PE1
P
via levels of Access Switch
KA
TC
1500
HA
PT
RH
Relay RH is operated during test for private guarding earth
Relay KA operates when position unequipped
1500
DR
DA
To Access Switch D.M via Dist. levels
This connection earthed on unequipped positions
DR
DA
DB
Relay DR is operated by interrupted earth pulses
DB
KA
DA
DB
TC
DA
DB

FIG. 9.

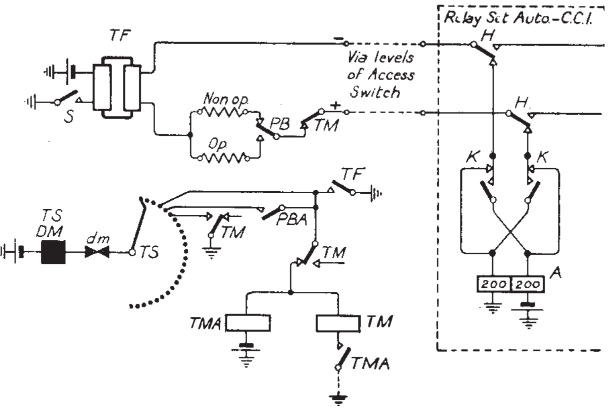


FIG 10*a*.

the battery condition on the incoming lines to the relay set is normal. Should the "A" relay operate with this current the reversal of the battery condition releases relay TF, thereby allowing TM to operate and lock, thus preventing further operation of the routiner. This being a negative test, a time delay has to be arranged by a group of relays, operated by pulses, of which relay PBA is the last to operate. Relay TF will not release when the A relay is in correct adjustment, and the test switch is therefore stepped in this case when PBA operates.

On the test switch stepping, after the "Non-operate" test, relay PB is operated to change the resistance of the loop in order to allow the operating current for the "A" relay to flow. The indication of satisfactory functioning under this test (being the reversal of the incoming lines) causes TF to release and TM to operate, thus stepping the test switch.

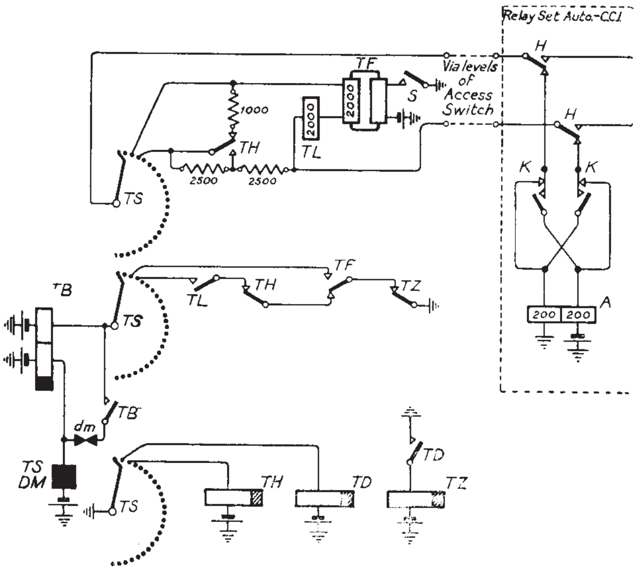


FIG. 10*b*.

Fig. **10***b* shows a modified form of this circuit for obtaining the same result, the delay period for the "Non-operate" test in this case being obtained by two slow relays TD and TZ releasing in tandem. An additional feature is incorporated for the "Operate" test which allows the current in the "A" relay to flow *via* a non-inductive circuit during the period of release of relay TH. This is to prevent the possibility of a premature release of the "A" relay, due to the inductive discharge from relays TL and TF should reversal occur before the current in the A relay had reached a certain value. It was found during tests that such release did occur when the coder finder seized an early choice coder.

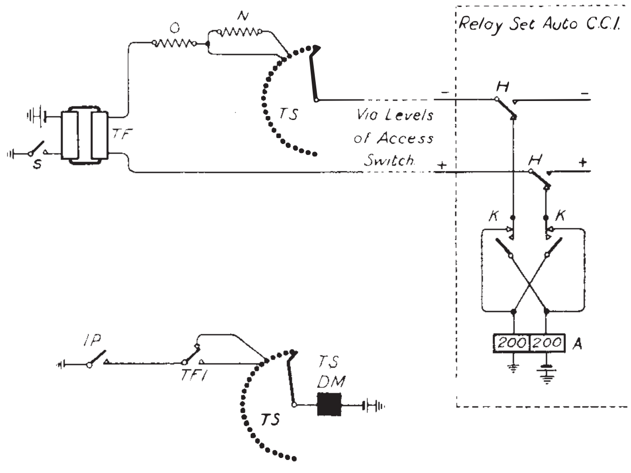


FIG. 10*c*.

In the standard routiner circuit the converse operation obtains, relay TF not operating when "Non-operate" conditions are applied and operating when the "Operate" current test is satisfactory as shown in Fig. **10***c*.

The routiner now sends a four digit number in order to cause the coder to send. Since the adjustment of the "A" relay has been checked, it is considered unnecessary to send trains of impulses for this purpose; four digits of one impulse each are therefore used.

Fig. **11***a* shows one of the methods employed for sending and receiving the digits. Relay TM is operated on contact 7 of the Test Switch and prepares relays A and SA. Relay SA opens the short-circuit across the loop springs and pre-

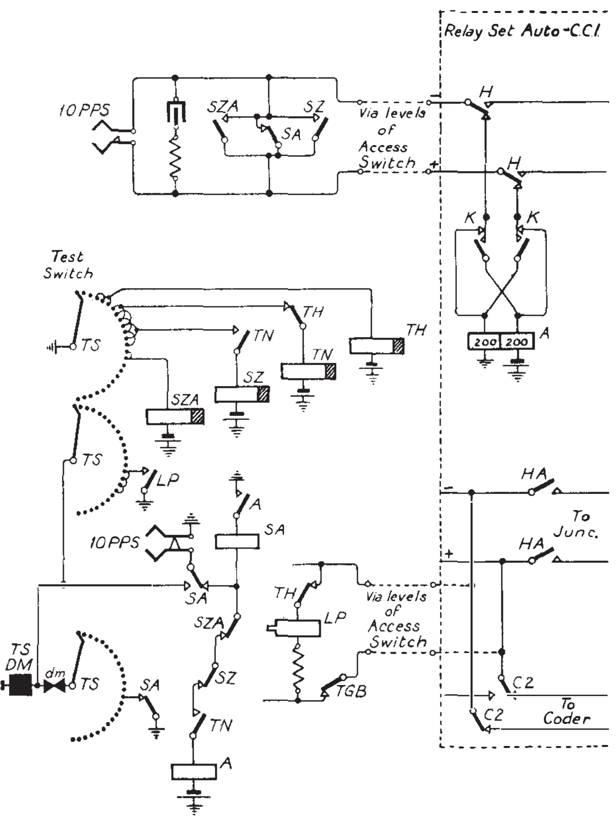


FIG. 11*a*.

pares for stepping the Test Switch. While the latter is energised, an impulse is sent to the relay set by the loop springs. The test switch then steps, relay SZ operates to short-circuit the loop springs and release A and SA. TN and SZ, being slow to release, give the necessary pause between the digits. When four such operations have been performed, relay SZA operates to prevent further digits from being sent.

Referring to Fig. **11***b* it will be seen that the counting of the digits is arranged by successive operations of four " Two-Step " relays designated E—H, the operation of relay H stepping the Test switch to prepare the routiner for receiving the coded digits *via* relay LP, the circuit of which is also shown in Figs. **11***a* and **11***b*. Relay LP is a polarized relay similar to that employed in the " C.C.I. Decoder " and is arranged to operate with each " Light Positive " pulse received from the " Coder." Each digit comprises one " Light Positive " pulse in addition to other pulses, and the " Test Switch " is therefore stepped over four contacts, indicating that the four digits have been received.

There is a disadvantage in checking the receipt of the positive pulses only; should the positive lead from the " C.C.I. Relay Set " to the Coder be earthed this fault would not be discovered. The standard circuit has therefore been so arranged that the routiner " Test Switch " is stepped by the positive pulses of the four digits and then the two " Light Negative " pulses of the last digit are also checked.

When the Coder has sent all four digits the C.C.I. Relay Set should guard the incoming private until the call has been cleared at the Manual Exchange, in order to prevent wrong connections in the event of a premature clear by a calling subscriber. This guarding condition is checked by means of relay PT, shown in Fig. **9**. Relay PT is an earthed relay of low resistance and is normally connected to the private,

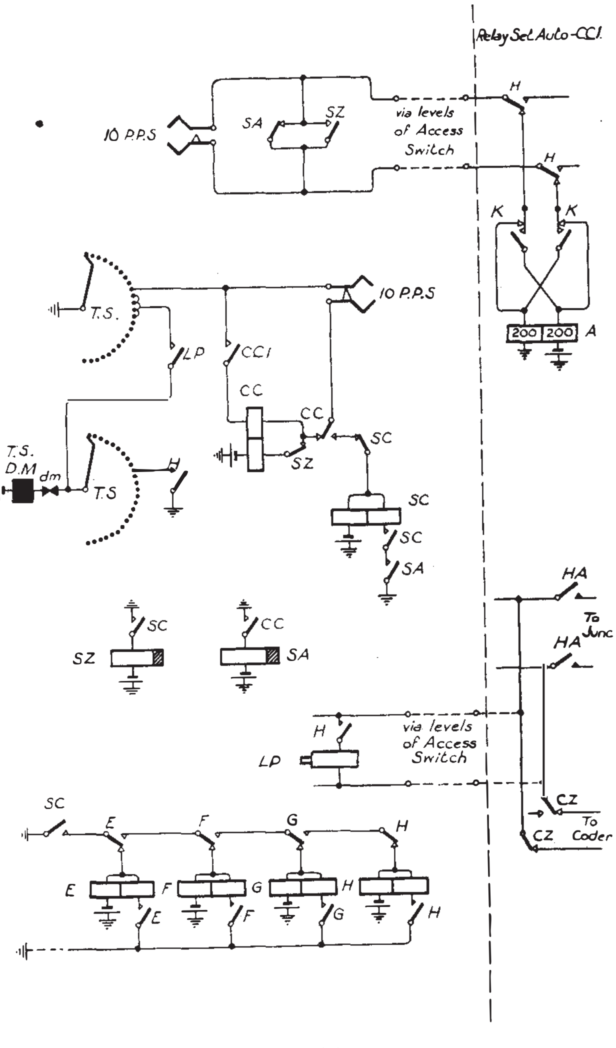


FIG. **11***b*.

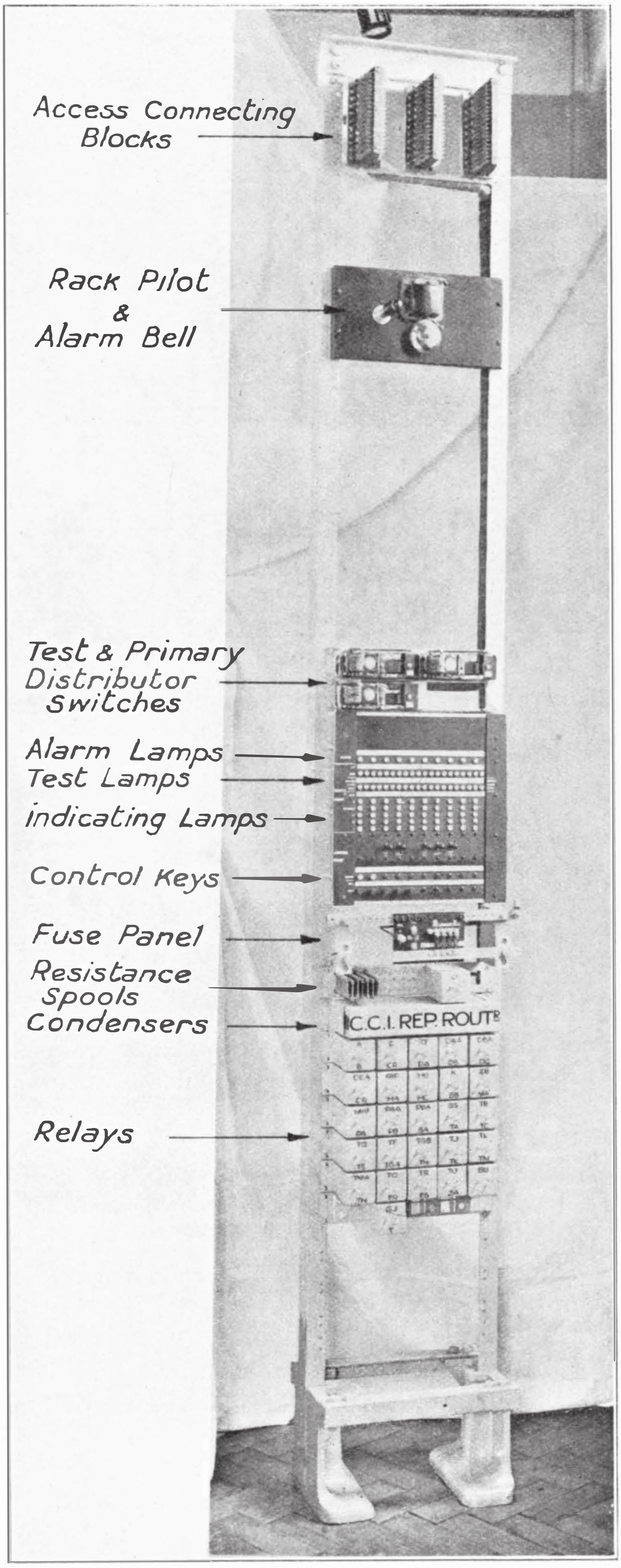


FIG. 12.—C.C.I. SET ROUTINER.

thereby providing the routiner guarding condition while testing is in progress. When it is required to check the "Relay Set" earth, battery, *via* a suitable protective resistance, is connected to the private by relay RH; thus, while the private is earthed, relay PT remains short-circuited, but should it be disconnected or earthed *via* a high resistance PT will operate and give an alarm.

The H relay of the Relay Set is now operated, the worst working conditions of line and battery being simulated and the through connections are checked. This test is of a simple character, the check for continuity and the presence of extraneous earth or battery conditions only being necessary.

In the standard circuit, relay HA is connected to the private, as shown in Fig. **7**, and it is desirable that the holding circuit *via* contact HA1 shall be checked. To accomplish this, it is necessary to arrange the sequence of tests so that relay HA is operated before relay H. The sequence is therefore arranged as follows:—When the private has been tested for guarding earth ("CZ Operated" Test), relay HA is re-operated by removing the short-circuit, and the earth on the positive junction line is thus extended to operate relay H. The latter relay causes relay K to release and the "Coder Finder" to "home," and then relay CZ releases. CZ releasing removes earth from the private thereby removing the short-circuit from relay PT, which operates in series with relay H in the Relay Set and steps the "Test Switch." Thus the operation of relay H and the homing of the Coder Finder are checked. The holding circuit of relay HA is now tested by stepping the "Test Switch" with interrupted earth, the stepping circuit being dependent on the receipt of earth on the positive line of the junction.

"Fault Imitation" keys are provided in this routiner to check the operation of the routiner under the following conditions:—"Junction Reversed," "Junction Disconnected" and "Relay Set Busy."

The delay periods before alarms are given are 3 minutes for faults and 9 seconds approximately for release alarm.

Fig. **12** shows the lay-out of apparatus on a typical C.C.I. Relay Set Routiner rack.

THE LONGITUDINAL DISTRIBUTION OF MUTUAL ELECTRIC CAPACITY IN TELEPHONE CABLE CIRCUITS AND ITS EQUILISATION.

A. Morris, M.I.E.E., and G. W. Hodge.

SYNOPSIS.—Deals with the non-uniformity of M.E.C. in coil loaded telephone cables as a cause of irregularity of their impedance-frequency characteristics. Gives definitions relating to, explains a method of analysis of uniformity of and describes the technique of equalisation of longitudinal distribution of M.E.C. Furnishes scheduled data in respect of manufacturing and loading section lengths. Presents curves of capacity distribution and of impedance-frequency characteristics for cables of modern and earlier type, in illustration of recent improvements.

Introduction.—Electric capacity equalisation along the length of loaded trunk cable circuits, for the purpose of ensuring efficient two-wire telephonic repeater working, is quite distinct from electric capacity balancing for interference immunity purposes. Capacity balancing is directed towards securing symmetry of those electrical systems of the cable comprised of possible interfering elements and is based upon a consideration of the direct wire-to-wire and the direct wire-to-earth capacities within such systems. Longitudinal equalisation of capacity aims at securing a uniform and similar distribution of mutual electric capacity along the length of the various circuits of a cable. For long-distance duplex repeatered cables capacity equalisation is undertaken additionally to capacity balancing, since interference immunity may be secured even with non-uniform longitudinal distribution of capacity, provided such distribution is symmetrical, *i.e.*, exactly similar for each of the elements comprising such a system.

Two-wire duplex repeater working.—For two-wire duplex repeater working it is necessary to provide at each repeater along the circuit a line-balancing or line-compensating network. The impedance of this network simulates that of the line to which it is connected at all frequencies comprised in that portion of the audio frequency range which it is necessary to freely transmit in order to ensure intelligibility.

The nearer the impedance of the balancing network simulates that of the line the smaller will be the circulating currents which tend to cause the repeater to oscillate or " sing " and the higher the amplification at which the repeater can be effectively worked.

Fig. 1 shows the variations, with frequency, of the characteristic impedance of a certain medium heavy coil loaded underground circuit. The reactance and effective resistance components of the impedance are shown separately. Each curve may be considered to consist of a main curve, called the " Smooth Mean Curve," with a number of superposed humps.

In working this particular circuit with two-wire duplex repeaters it would be desirable to construct a line balancing network whose impedance-frequency characteristic simulated that shown in Fig. 1. Such a network would be complicated and bulky. In practice a network would be constructed to simulate " the smooth mean curve " of Fig. 1.

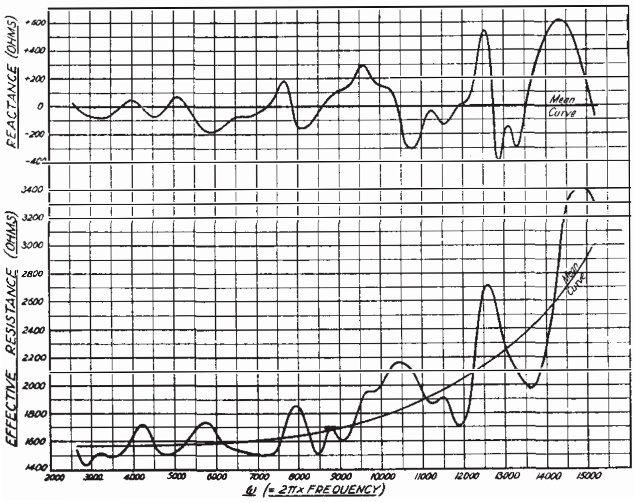


Fig. 1.

Assuming a network which simulates the smooth mean curve of the line, then, for each frequency at which the smooth mean and actual line impedance curves do not coincide the impedance of the balancing network will differ from that of the line and a current will circulate around the repeater tending to cause it to " sing."

Apart then from other transmission considerations, a more efficient and satisfactory repeatered circuit will be obtained if the line is so constructed as to give a smooth impedance-frequency curve.

Causes of irregularities in impedance-frequency curves.—The humps or irregular variations in the impedance-frequency characteristic curves shown in Fig. 1 are caused by a portion of the power sent into the line being reflected from some point or points along the line at which one or more of the primary constants, resistance, inductance, mutual electric capacity (M.E.C.) or leakance of the line are not uniformly distributed with length.

Lump or coil-loaded cables by reason of their construction give in general, impedance-frequency curves of a humpy nature. If the electrical constants of the line were absolutely uniformly distributed with length then its impedance-frequency curve would be quite smooth. High grade continuously-loaded cables possess such characteristics.

In modern coil-loaded cables the length distribution of conductor resistance and of leakance is normally essentially uniform. Furthermore the inductance of loading coils and the lengths of loading coil sections of cable deviate to a very small extent from their respective average values. In the case, however, of the M.E.C. of cable circuits the manufacturing deviations have hitherto been of sufficiently large magnitude, as to give rise in repeatered circuits and particularly in those of relatively low " Cut-off," to electrical instability, owing to imperfect balance of the line and its network, long before the full amplification of the repeaters could be utilised. The necessity for special treatment of M.E.C. thus arises, and about the year 1923 the first attempts, on a large scale, at equalising the longitudinal distribution of the M.E.C. of cable circuits were made in this country.

The degree of loading employed has a direct bearing upon the magnitude of the variations, from a smooth curve, of the impedance-frequency characteristics of a circuit. For a given non-uniformity of length distribution of M.E.C. in a circuit, the heavier the loading of that circuit the greater will be the variations of the impedance-frequency characteristics from a smooth curve. This will be so for two reasons :—

(*a*) The heavier loading results in a smaller attenuation constant for the circuit, thus the magnitude of the reflected power arriving at the sending end is greater and the magnitude of the humps will thus be greater.

(*b*) The heavier loading results in a larger phase constant and therefore slower velocity of propagation. This will result in a greater number of humps over a given frequency range.

It has been found advantageous in the case of certain repeatered cables to decrease the loading of those circuits in which the impedance-frequency characteristics departed considerably from a smooth curve. The resulting increase of attenuation length of the line was, however, more than compensated by the increased amplification which could be utilised at the repeaters owing to the improvement in the impedance-frequency characteristics of the line.

Before proceeding to discuss the results obtained at these first attempts or the results obtained upon present day cables, certain fundamental definitions which have been adopted in connection with this subject will be given. These definitions are applicable not only to the manufacturing but also to the field constructional stages of the work. The figures for the various characteristics quoted in the British Post Office specifications for modern cables are also given.

Mutual Electric Capacity.—The M.E.C. of a circuit is the electric capacity measured between the two limbs of that circuit when all the other conductors in the cable and the cable sheath are earthed.

Mean M.E.C.—The Mean M.E.C. of a group of circuits of a cable length is the average or mean value of the individual capacities of each of the circuits of that length comprised in that group. In British cables the magnitude of the Mean M.E.C. of pair circuits expressed in microfarads per mile, must not be less than 0.057 nor greater than 0.067 in any factory length of a complete cable, whilst in each factory length of at least 90% of the total number of such cable lengths, 0.059 and 0.065 are the limiting values. These magnitudes correspond to 0.062 ± 8% and 0.062 ± 5% respectively. The Mean M.E.C. of the phantom circuits of any factory length are specified not to differ from 1.62 times the actual Mean M.E.C. of the pair circuits of that length, by more than 5%.

Average Mean M.E.C.—The Average Mean M.E.C. of a group of circuits in a number of lengths of cable is the average value of the mean capacities of that group in each individual cable length.

M.E.C. Deviations.—The circuits of a cable may be divided into groups for balancing purposes or for the special needs of particular kinds of circuit working, *e.g.*, four-wire repeater working, in which case one group will consist of " Go " circuits only and another group of " Return " circuits only. The grouping may be arranged in layers, or in sectors by means of a diametral separation. A combination of both methods may be used. Owing to the special features of cable manufacture it is seldom possible to obtain exactly the same value for the Mean M.E.C. of each layer, or of each group of any particular factory length, or exactly the same value for the Mean M.E.C. of a particular group in each length of complete cable. In addition the M.E.C. of any circuit of a cable length will generally differ from the Mean M.E.C. of all similar circuits (of the same group) of the same length. Similarly the M.E.C. of any circuit of a cable length will differ from the Average Mean M.E.C. of all similar circuits (of the same group) of a number of cable lengths. Furthermore, as already stated in other terms, the Mean M.E.C. of a group of circuits of a cable length will differ from the Average Mean M.E.C. (of that group) of a number of cable lengths. These differences are referred to as capacity deviations and are classified into " Circuit Deviations " and " Length Deviations " of capacity. Such deviations, although inherent to commercial processes, are capable of being maintained within narrow limits by careful supervision, inspection and testing and the application of modern methods of manufacture.

Circuit Deviation of M.E.C.—The M.E.C. deviation of a circuit is the difference (irrespective of sign) between the M.E.C. of that circuit and the Mean M.E.C. of all similar circuits of the same group in the same length, expressed as a percentage of the Mean M.E.C. of that group in that length.

In British cables, this quantity is specified not to exceed 12.5 per cent. for any factory length. For any circuit of a loading coil section a figure of 3 per cent. must not be exceeded, whilst for 95 per cent. of such circuits 2 per cent. is the limiting value.

Mean Circuit Deviations of M.E.C. — The mean M.E.C. circuit deviation of a group of circuits of a cable length is the sum of the circuit deviations, irrespective of sign, of all the similar circuits in the same group in the same length divided by the number of such circuits, the result being expressed as a percentage of the Mean M.E.C. of that group of circuits in that length.

In British cables this quantity is specified not to exceed 4 per cent. for either the pair or phantom circuit of any factory length. The maximum circuit deviation allowed in loading sections of cable is 3 per cent.; the mean circuit deviation will therefore be very small and it is accordingly not specified.

Length Deviation of M.E.C. of a Group of Circuits of a Cable Length.—The length deviation of M.E.C. of a group of circuits of a cable length is the difference between the Mean M.E.C. of the circuits (of that group) of that cable length and the Average Mean M.E.C. of the circuits (of that group) of all the similar cable lengths of the complete cable, expressed as a percentage of that Average Mean M.E.C.

In British cables this quantity is specified not to exceed 2 per cent. for either the pair or phantom circuits of any loading coil section. Furthermore adjacent loading sections must not differ from each other in this respect by more than 3 per cent.

Length deviations of M.E.C. are not specified by the British Post Office for factory lengths of cable, sufficiently narrow limits in this respect being secured by the practical operation of the clauses which limit the magnitude of the Mean M.E.C. of side and phantom circuits.

M.E.C. of the Circuits of Factory Lengths of Cable.—For any particular length of cable there will be a certain value for the mean circuit deviation and a certain value for the maximum circuit deviation. Each of these quantities will generally be of different respective value in one cable length from what they are in another. In the analysis of such data for the purpose of presenting in a brief but comprehensive form, information as to the order of magnitude of the circuit deviations for the whole of the lengths of a complete cable it will be necessary to obtain average and maximum values of each of the previously mentioned quantities, as in the analagous case of capacity unbalance analyses.

Table No. 1 gives the magnitude of the circuit and length deviations of M.E.C. for the factory lengths of a repeater section of 60/40 M.T. cable. The Average Mean M.E.C. of the various layers and groups are also included in the Table.

M.E.C. Uniformity Requirements for Repeatered Cables.—Considering for the moment one circuit in a repeater section of cable not only should (i) the length deviations of M.E.C. of each portion of it situated between loading coils, *i.e.*, of each loading section, be as small as possible, but in addition (ii) the length deviations of M.E.C. of adjacent loading sections should not be widely different from one another.

As already mentioned, values not exceeding 2 per cent. and 3 per cent. for (i) and (ii) respectively are specified in British cable practice.

In considering the whole of the circuits of any particular group of a repeater section of cable it is highly desirable that (iii) the circuit deviations of M.E.C. be as small as possible in order that with the consequent similarity of M.E.C. of such circuits a standard basic network may, with minor adjustments, be applicable to the whole of the circuits of the group. In order to secure this advantage in British cables the circuit deviation of any circuit of any group in any loading section is specified not to exceed 3 per cent. whilst the individual circuit deviation of 95 per cent. of such circuits must not exceed 2 per cent.

The capacity requirements (i), (ii) and (iii) are secured in modern cables almost entirely by limiting the circuit and length deviations of M.E.C. in the manufacturing stage of the work. In conjunction with the exercise of manufacturing control, grading or the allocation of factory lengths to definite loading sections is also resorted to with a view to minimising length deviations of M.E.C. of loading sections. Thus the Mean M.E.C. of the circuits of factory lengths is required to be of such magnitude that when suitably allocated the length deviations of the loading sections shall not exceed 2 per cent.

Selected Jointing of Factory Lengths of Cable to ensure equalisation of the M.E.C. of the Circuits of Loading Sections.—In those cases where the circuit deviations of the factory lengths are so near the specified maxima that requirement (iii) above, is, in the absence of special precautions, unlikely of achievement, adjustment will be necessary during the constructional stages of the work. It is interesting to note in this connection that if $\triangle$ is the average mean circuit deviation of the factory lengths of a repeater section of cable, then in the absence of special capacity adjustment δ the probable average mean circuit deviation of the loading sections is given by $\delta = \frac{\triangle}{\sqrt{N}}$ where N is the number of factory lengths per loading section. The adjustments referred to are effected generally during the jointing of the factory lengths into loading sections by the use of the crossing method, a circuit with a positive deviation in one length being connected to a circuit of equal (or as nearly equal as possible) negative deviation in an adjacent length. Such adjustments will generally require to be made, if at all, at one joint only, and this can conveniently be the middle or final joint of a loading section at which crossing for interference immunity purposes would normally be of secondary importance. The process follows the systematic lines of measurement and selection adopted in capacity balancing for interference immunity purposes. Whereas direct capacity unbalances are normally measured in this latter case, mutual capacities will of course require to be determined in the case of capacity equalisation.

During the selecting processes, the assumption is made that the arithmetic sum of two M.E. Capacities is the resultant M.E.C. of two M.E. Capacities connected in parallel. This is not absolutely accurate, but the discrepancy involved provided there is reasonable symmetry of the earth components of such M.E. Capacities is negligibly small.

The selecting work is relatively easy since pair crosses only are of utility for pair circuit adjustments, whilst core crosses only are of utility for phantom circuit adjustments. It should be noted in this connection that a wire cross in connecting two pairs together will not affect the M.E.C. of the complete pair circuit unless there is considerable asymmetry of the earth capacities of the wires of the pairs, whilst a pair cross in connecting two cores together will not affect the M.E.C. of the phantom circuit unless there is considerable asymmetry of the earth capacity of the pairs of the cores.

It is obviously impossible to alter the Mean M.E.C. of the circuits of a loading section by the previously described field operations, involving selecting and jointing. Capacity adjustments may, however, be effected in the field by the artificial addition of capacity to cable circuits, either by means of additional cable or by the use of condensers. This method is not generally regarded as entirely satisfactory and in view of the availability of other means is not used in the construction of British cables. Thus the Mean M.E.C. of the factory lengths may be controlled within definite limits by careful manufacture, whilst by grading, the Mean M.E.C. of such loading sections may be made to approximate closely to the Average Mean M.E.C. of the whole cable.

In those cases where, owing to unavoidable causes there are differences in the lengths of loading sections along a route, it would be necessary in order to meet the fundamental requirement of equality of M.E.C. per loading section, to so manufacture or allocate the single lengths comprising such sections as to secure the desired result. The importance of the drum sections being of equal length and of the lengths of loading sections deviating by as small a value as possible from the average length of all the loading sections along the route, will be obvious from these considerations.

Examination of the Magnitude and Distribution of M.E.C. in the Circuits of Repeater Sections of Cable.—By plotting the value of the mean, maximum and minimum M.E. capacities for each group of circuits for each loading section, an analysis may be made of the magnitude and distribution of the M.E.C. of the circuits of a repeater section of cable. In the case of end sections, which differ materially in length from the normal loading section length, the Mean M.E.C. values for such sections will require to be converted to equivalent values for a normal length loading section.

In addition to plotting the mean, maximum and minimum capacities of each group of circuits for each loading section, a straight line representing the Average Mean M.E.C. per group per normal loading section of the whole cable should also be drawn. A specimen example of such a plot is given in Fig. **2**, which gives the results obtained for a group of 20 lb. circuits in a composite cable containing 20 lb. and 40 lb. circuits.

The results for the pair circuits are shown as wire-to-wire values, those for the phantom circuits as pair-to-pair values.

The straight full line represents the Average Mean M.E.C. per normal loading section. The dashed straight lines represent capacities 2% greater and 2% less respectively than the Average Mean M.E.C. per normal loading section.

The extent of the divergence of the mean line from the average mean line is indicative of the degree of uniformity of length distribution of M.E.C. of the circuits generally, large divergencies representing considerable non-uniformity and *vice versa*. In those cases where the divergencies are large, the causes are ascribable to non-uniform manufacture and ineffective grading.

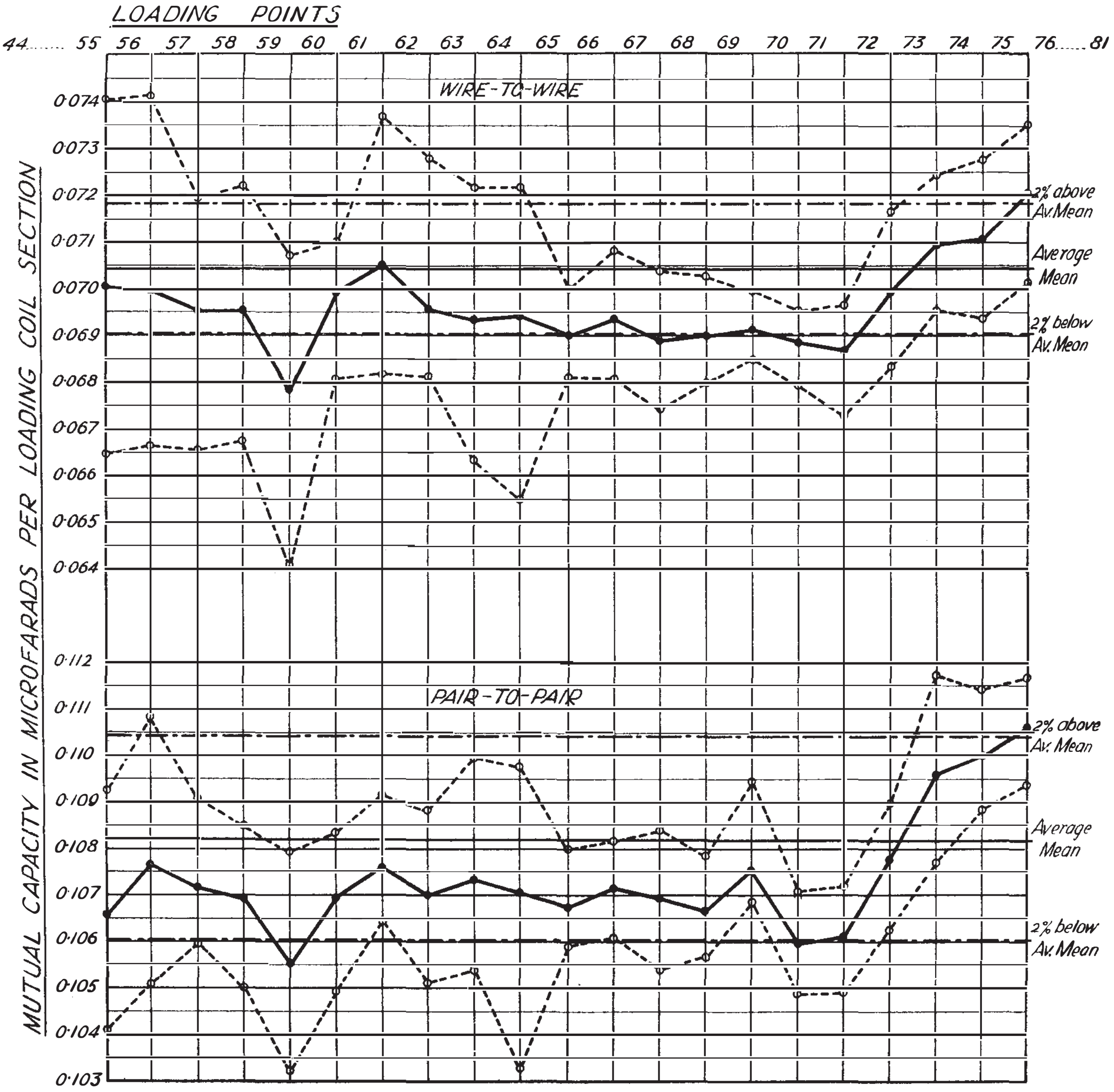


Fig. 2.

The distance between the maximum and minimum lines at any point is generally referred to as the "Band Width." Narrowness of "Band Width" is indicative of small circuit deviations; this may be achieved directly by high grade manufacture or it may result from the special test jointing of less-perfectly manufactured factory lengths.

In the example given in Fig. **2** no attempts at M.E.C. equalisation were made during the construction of loading sections 45 to 65. The large circuit deviations and consequent large "Band Width" will be observed. The length deviations are also considerable. From loading section 66 onwards, attempts at M.E.C. equalisation were made. In the case of this cable no grading was undertaken. Thus the only result of the equalising operations was to reduce the circuit deviations, the length deviations remaining at essentially the same magnitude as for loading sections 45-65. This must be so since the Mean M.E.C. of the circuits of any loading section cannot be controlled by selection between the manufacturing lengths of that loading section. The only control, other than that of manufacture, over the Mean M.E.C. of the circuits of a loading section is that of grading.

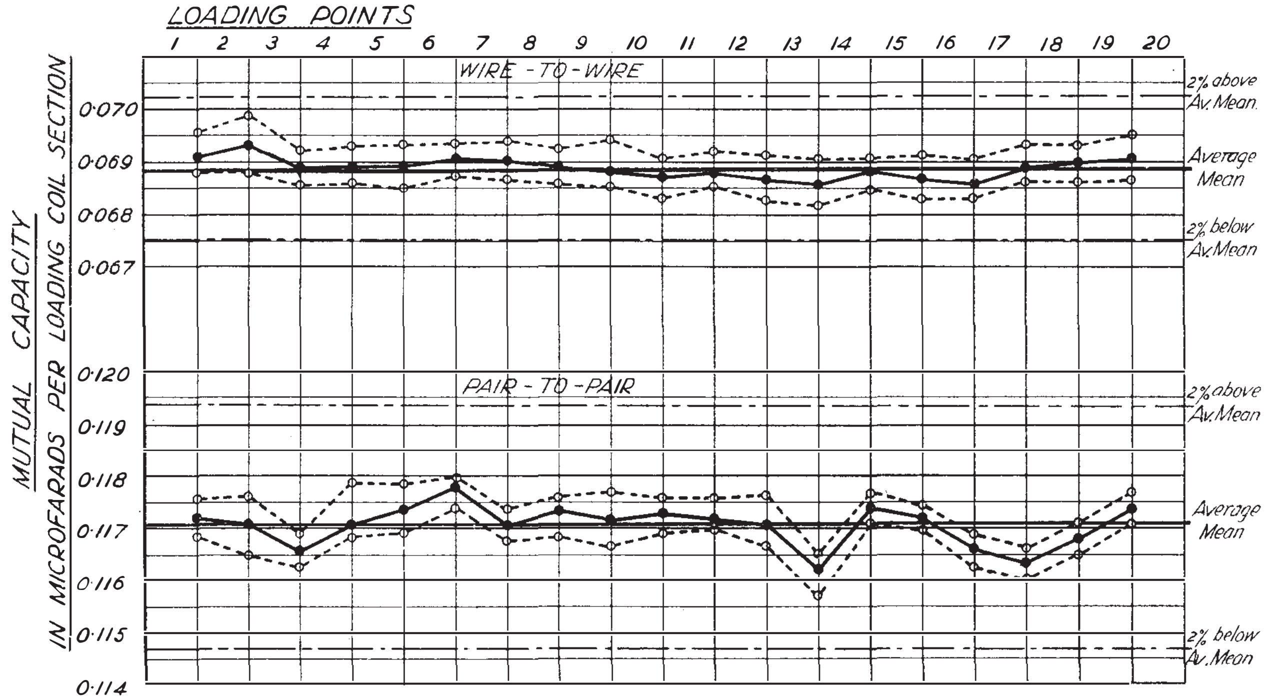


Fig. 3.

Fig. **2** is a plot of the results obtained on load-coil sections in one of the first cases in this country of M.E.C. equalisation by means of field operations. A scheduled analysis of the plot is given in Table No. 2.

The results for the loading sections of a cable recently manufactured and whose factory length characteristics are given in Table No. 1 are shown plotted in Fig. **3**. A scheduled analysis of the plot is given in Table No. 3.

A comparison between Fig. **2** and Fig. **3** and Tables No. 2 and 3 shows at once the considerable improvement in the uniformity of distribution of M.E.C. which has resulted from the more careful manufacture of the factory lengths of cable, supplemented by work in the field.

Selected Jointing of Loading Sections to ensure M.E.C. equalisation along the Length of Circuits comprising Repeater Sections.—Referring to the loading sections:—

(*a*) If both circuit and length deviations of M.E.C. are small, further selection will be unnecessary since the circuits are essentially uniform. This is the condition to be aimed at in telephone cables generally and can only be satisfactorily ensured by high grade manufacture and the exercise of the precautionary measures in primary field constructional work, already described.

(*b*) If length deviation is large and circuit deviation is small, practically no improvement is obtainable by selection between loading sections.

(*c*) If circuit deviation is large and length deviation is small, then in order to preclude the possibility of pairs of large capacity in one loading section being joined to pairs of low capacity in an adjacent loading section, test selected jointing of the loading sections is advantageous and desirable.

(*d*) If both the circuit deviations and length deviation are large, it will usually be possible by test-selected jointing between the loading sections to ensure uniformity of length distribution of M.E.C. in a proportion of the circuits of the complete cable. These selections are carried out with a view to ensuring a number of circuits (in certain groups) for satisfactory duplex repeater working. Such circuits will accordingly receive prior consideration. In these circumstances the remaining cable circuits will generally be more irregular than if test-selected jointing between the loading sections had not been resorted to. It is desirable, of course, to include both side and phantom circuits in these selections, but because of the additional complication involved and because such a procedure seriously limits the improvement possible in the side circuits besides limiting interference immunity adjustments which would otherwise be normally considered at this stage of the construction work, it is seldom attempted.

In the case of the example given in Fig. **2** it was necessary to select the joints between the loading sections, in order to obtain a number of circuits in which length deviation of M.E.C. would not be large. The circuits so obtained were used for special two-wire duplex repeater working and the repeaters in these circuits could be worked at a higher gain than those in the remaining circuits.

Impedance-Frequency Characteristics of a completed Cable manufactured to present day specifications for M.E.C.—Fig. **4** gives the impedance-frequency characteristics for a recently completed medium heavy coil-loaded cable. It will be seen by comparing Fig. **4** with Fig. **1** that the impedance frequency curves of Fig. **4** are much less irregular than those of Fig. **1**. In the case of the cable concerned in Fig. **4** all similar circuits, *i.e.*, similarly loaded circuits in the same group, had practically the same impedance-frequency characteristics. This is a decided advantage since if desired it is possible to design one type of balancing network for each type of circuit and the singing points of the repeaters will be but little different from those obtained by the construction of individual balances.

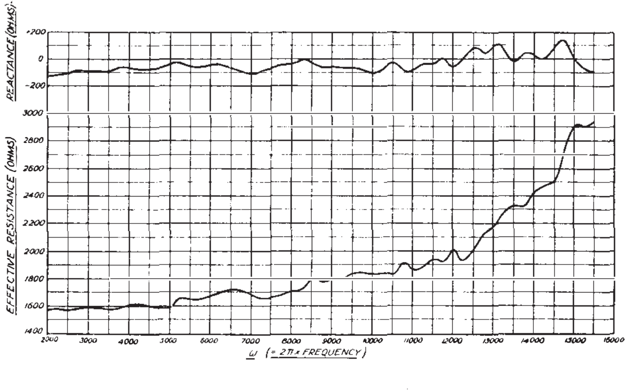


FIG. **4**.

Replacing a Factory Length of a Loading Section originally test-jointed for mutual capacity equalisation.—Cases will arise when owing to a fault or some other cause a new length of cable will require to be inserted in a loading section, originally test-jointed for mutual capacity equalisation. In such cases, in addition to capacity balancing for interference immunity, test-jointing for longitudinal uniformity of M.E.C. of the circuits of that loading section will also be required.

It has already been pointed out that the Mean M.E.C. of the circuits of a loading coil section cannot be controlled by selection between the various lengths of cable forming that loading coil section. Only circuit deviation of M.E.C. can be controlled by selection in such a case. Thus in the case of the replacement of a length of a loading section as soon as the particular replacing length has been decided upon, the only result which can be accomplished by subsequent selection is the reduction of the magnitude of the Circuit Deviations of the circuits over the reconstituted loading section.

TABLE No. 1.

ACTUAL CAPACITY DEVIATIONS OF THE FACTORY LENGTHS OF A REPEATER SECTION OF 60/40 M.T. CABLE.

Circuits.	Side.			Phantom.		
Layer.	C	1st	2nd	C	1st	2nd
Average Mean Mutual ... ... Capacity (μF. per mile)	0.0627	0.0614	0.0616	0.1004	0.1002	0.1039
Groups.	1st		2nd	1st		2nd
Average Mean Mutual ... ... Capacity (μF. per mile)	0.0615		0.0616	0.1003		0.1039
Circuit Deviations %.						
Average Mean	1.45		1.35	0.79		0.74
Maximum Mean	2.25		2.30	1.45		1.45
Average Maximum	4.00		3.50	1.80		1.70
Maximum Maximum	10.21		9.75	6.23		5.82
Length Deviations %.						
Mean	1.14		1.14	1.99		1.15
Maximum	3.74		5.03	3.50		6.94

TABLE No. 2.

ACTUAL CAPACITY DEVIATIONS OF THE LOADING COIL SECTIONS OF A GROUP OF 20LB. CONDUCTOR CIRCUITS OF A REPEATER SECTION OF A COMPOSITE CABLE CONTAINING 20LB. AND 40LB. CIRCUITS.

Circuits.	Side.	Phantom.
Layer.	4th	4th
Group.	3rd	3rd
Average Mean Mutual ... ... Capacity (μF. per mile)	0.0626	0.0962
Circuit Deviations %.		
Average Maximum	3.67	1.96
Maximum Maximum	7.02	4.44
Length Deviations %.		
Average	1.49	1.26
Maximum	3.69	2.68
Maximum Difference between Adjacent Normal Length L.C.S's. %	3.84	2.59
Ratio. Phantom Capacity ... ... Side Capacity	1.54	
End Sections.		
Circuit Deviation %. Maximum	5.15*	3.26*
Length Deviation %. Maximum	11.2*	9.6*
Maximum Difference between Adjacent L.C.S's. %	14.6*	11.7*

* Indicates end section of short length, the results for which have been converted to the equivalent values for a normal length loading coil section.

TABLE No. 3.

ACTUAL CAPACITY DEVIATIONS OF THE LOADING COIL SECTIONS OF A REPEATER SECTION OF 60/40 M.T. CABLE.

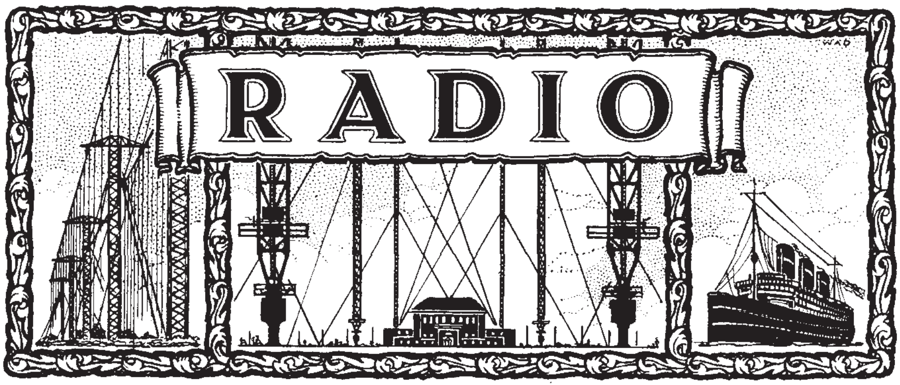
Circuits.	Side.		Phantom.	
Layer.	C 1st	2nd	C 1st	2nd
Groups.	1st	2nd	1st	2nd
Average Mean Mutual ... ... Capacity (μF. per mile)	0.06056	0.06121	0.09898	0.10404
Circuit Deviations %.				
Average Maximum	0.56	0.61	0.33	0.35
Maximum Maximum	1.61	0.99	0.48	0.61
Length Deviations %.				
Average	0.66	0.31	0.57	0.33
Maximum	1.48*	1.65*	1.20	1.50*
Maximum Difference between Adjacent Normal Length L.C.S's. %	0.94	0.67	1.18	1.07
Ratio. $\frac{\text{Phantom Capacity}}{\text{Side Capacity}}$	1.63	1.70		
End Sections. *Circuit Deviations %.* Maximum	1.77*	4.38*	1.60*	1.50*
End Sections. Maximum Difference between Adjacent L.C.S's. %	2.89*	2.00*	0.91*	1.38*

* Indicates end section of short length, the results for which have been converted to the equivalent values for a normal length loading coil section.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 31ST MAR., 1929.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
633,089	517	3,985	51,880	112	London	24,892	75,197	2,444,896	119,009
80,801	2,158	20,798	66,223	2,528	S. East	4,059	53,741	223,213	27,950
84,349	4,533	31,445	58,487	3,186	S. West	20,843	13,192	164,666	58,982
66,564	6,005	38,387	61,577	4,611	Eastern	24,175	40,999	128,542	66,788
99,726	8,457	45,265	60,190	3,890	N. Mid.	31,859	55,703	251,178	107,102
82,537	4,774	30,228	73,549	4,396	S. Mid.	12,233	24,799	204,340	86,992
59,401	4,850	29,909	54,115	3,348	S. Wales	6,599	26,584	125,947	71,504
107,747	8,011	26,411	51,091	4,463	N. Wales	13,897	40,309	284,746	62,042
162,580	1,473	15,672	43,881	3,157	S. Lancs.	14,178	81,079	487,843	49,467
95,180	6,212	30,445	47,311	3,438	N. East	12,485	44,924	247,127	75,319
65,685	3,913	23,819	38,520	2,835	N. West	8,860	35,084	173,716	31,065
48,536	2,565	16,133	25,823	2,672	Northern	5,350	18,838	113,733	45,230
22,039	4,557	8,516	13,657	538	Ireland N.	135	2,327	45,325	1,557
67,625	5,445	26,867	38,523	1,231	Scot. East	5,231	13,785	156,687	44,783
90,068	7,253	24,459	43,505	1,053	Scot. West	12,360	25,527,	227,832	35,522
1,765,927	70,723	372,339	728,332	41,458	Total	197,156	552,088	5,279,791	883,312
1,727,680	70,604	373,013	720,356	39,941	Figures as at 31st Dec., 1928.	192,360	543,639	5,177,395	888,278



THE PRAGUE CONFERENCE.

A CONFERENCE was held at Prague, from the 4th to the 13th April, to discuss various radio questions affecting the Continent of Europe. All the European nations, with the exception of Lithuania, were represented and, in addition, delegations from Egypt and the United States of America were present.

Various minor questions affecting aeronautical, meteorological and police services were discussed, but the major question before the Conference was the Broadcasting situation in Europe.

In the early days of Broadcasting it became evident that the haphazard distribution of wave-lengths, which was then prevalent, caused a large amount of interference which considerably limited the service area of the Broadcasting stations in various countries. The principal Broadcasting interests combined to form the Union Internationale de Radiophonie, with headquarters at Geneva, with the object of endeavouring to straighten out the complex situation which had arisen. The first result of the work of the Union was the " Plan de Geneve," which was an attempt to divide the available wave-lengths between the Broadcasting Stations in Europe. This plan effected some improvement, but was only partially successful because the Union was not officially recognized in certain countries.

At a later stage a second attempt was made to divide the available wave-lengths, the result being known as the " Plan de Bruxelles." This plan suffered the same fate as its predecessor, and the Government of Czecho Slovakia offered to call an official conference to consider the matter.

The principal question before the Conference was the status of the Union Internationale de Radiophonie. After very long and heated discussions the Conference agreed to recognize the Union in its quality of a body of Broadcasting experts. Government representatives are to be allowed to take part in the discussions of the Union on technical questions, when they desire to do so, and the rearrangement of wave-lengths within the Broadcasting Bands is to be left to the Union. Failing agreement on any question, and provided a majority of the European States desire it, a major Governmental Conference would be called to endeavour to arrange the matter.

Once this knotty political problem had been settled all was plain sailing. A small sub-committee concentrated on a new plan, the " Plan de Prague." Using the Plan de Bruxelles as a basis, each nation stated its desires and its grievances and an endeavour was made to satisfy as many peope as possible. Naturally, everybody could not be satisfied because there are not enough wave-lengths to meet the demand, but the Conference as a whole approved the Plan de Prague and arranged for it to be put into operation on the 30th June, 1929.

The Conference at Prague marks a new step in European radio affairs. Formerly the policy of first come first served was the rule in wave-length distribution. This is the first time the Governments of European States have concurred in a wider, more humanitarian, view that the last comer, or the smallest State, is entitled to share in the artistic and cultural benefits of Broadcasting, and that a distribution of wave-lengths based on the essential needs of the countries concerned should take the place of the more crude policy of grab.

That an agreement on these lines was possible is a credit to the pioneer work done by the Union de Radiophonie, but also to the broad-minded policy of the delegates of the principal countries concerned.

It remains to be seen whether the policy, now established for Broadcasting, will be extended to the wider fields of commercial radio telegraphy and telephony.

Here follows a reprint of the " Plan de Prague " :—

REDISTRIBUTION OF WAVE LENGTHS.

Following the " Plan de Prague," coming into force on the 30th June, 1929.

Frequencies in Kilocycles.	*Wavelengths in metres (approx.)*	*Name of Country.*	*Station.*
160	1875	Holland	Huizen
167	1800	Finland	Lahti
174	1725	France	Radio, Paris
183.5	1635	Germany	Zeesen
193.0	1553	Great Britain	Daventry
202.5	1481	Russia	Moscow*
207.5	1444	Aerial Services and Eiffel Tower	
212.5	1411	Poland	Warsaw
217.5	1380	Aerial Services	
222.5	1348	Sweden	Motala
230	1304	Russia	Kharkof*
250	1200	Turkey	Stamboul†
		Iceland	Reykjavik†
260	1153	Denmark	Kalundborg
280	1072	Norway	(X)†
297	1010	Switzerland	Bale†
320	938	U.R.S.S.	Moscow C.C.S.P.*
364	825	U.R.S.S.	Moscow*
375	800	U.R.S.S.	Kief*
385	778	U.R.S.S.	Petrozavodsk*
395	760	Switzerland	Geneva†
442	680	Switzerland	Lausanne†
527	572	Germany	Friburg†
		Serbia	
531.5	565	U.R.S.S.	Smolensk*
536	560	Germany	Augsbourg†
			Hanover†
545	550	Hungary	Budapest‡
554	542	Sweden	
563	533	Germany	
572	525	Littonia	
581	517	Austria	
585.5	511	U.R.S.S.	Archangel*
590	509	Belgium	
599	501	Italy	
603.5	497	U.R.S.S.	Moscow*
608	493	Norway	
617	487	Czechoslovakia	
621.5	483	U.R.S.S.	Gomel*
626	479	Great Britain	
630.5	476	U.R.S.S.	Simferopol*
635	473	Germany	
644	466	France	Lyons
653	459	Switzerland	
666.5	450	U.R.S.S.	Moscow S.P.*
662	453	Commune No. 1	
671	447	France	Paris P.T.T.
680	441	Italy	
689	436	Sweden	
698	429	Serbia	
702.5	427	U.R.S.S.	Kharkof*
707	424	Spain	
716	418	Germany	
725	413	Ireland	
729.5	411	U.R.S.S.	Odessa*
734	408	Poland	
743	403	Switzerland	
747.5	401	U.R.S.S.	Koursk*
752	399	Great Britain	
761	394	Roumania	
770	390	Germany	
779	385	Poland-Italy§	
783.5	383	U.R.S.S.	Dnepropetrovsk*
788	381	France	
792.5	379	U.R.S.S.	Artemovsk*
797	377	Great Britain	
806	372	Germany	
810.5	370	U.R.S.S.	Tver*
815	368	Spain	
819.5	366	U.R.S.S.	Nikolaief*
824	364	Norway	
833	360	Germany	
842	356	Great Britain	
851	352	Austria	
855.5	351	U.R.S.S.	Leningrad*
860	349	Spain	
869	346	France	Strasburg
878	342	Czechoslovakia	
887	339	Belgium	
891.5	337	U.R.S.S.	Ivan-Voznesensk*
896	335	Poland	
905	332	Italy	
914	329	France	Montpellier
923	325	Germany	
932	322	Sweden	
941	319	Bulgaria	
950	316	France	Marseilles
959	313	Poland	
968	310	Great Britain	
977	307	Serbia	
986	304	France	Bordeaux Lafayette
995	301	Great Britain	
1004	298	Holland	
1013	295	Esthonia	
1022	293	France and Czechoslovakia	Limoges
1031	291	Finland	
1040	289	Great Britain	
1049	286	France	Rheims
1058	283	Portugal	
1067	281	Denmark	
1076	279	Czechoslovakia	
1085	276	Germany	
1094	274	Italy	
1103	272	France	Rennes
1112	270	Greece	
1121	268	Spain	
1130	265	France	Lille
1139	263	Czechoslovakia	
1148	261	Great Britain	
1157	259	Germany	

Frequencies in Kilocycles.	*Wavelengths in metres (approx.)*	*Name of Country.*	*Station.*
1166	257	Sweden	
1175	255	France	Toulouse P.T.T.
1184	253	Germany	
1193	251	Spain	
1202	250	Czechoslovakia	
1211	248	Italy	
1220	246	Commune No. 2	
1229	244	Albania (provisionally Poland)	
1238	242	Great Britain	
1247	240	Norway	
1256	239	Germany	
1265	237	Monaco—Nice—Corsica (divided)	
1274	235	Norway	
1283	234	Poland	
1292	232	Serbia	
1301	231	Sweden	
1310	229	Spain	
1319	227	Germany	
1328	226	Roumania	
1337	225	Ireland	
1346	223	Luxembourg	
1355	221	Finland	
1364	220	France	
1373	218	Commune No. 3	
1382	217	Commune No. 4	
1391	216	Commune No. 5	
1400	214	Poland	
1410	213	Italy	
1420	211	Roumania	
1430	210	Hungary	
1440	208	Belgium	
1450	207	Commune No. 6	
1460	206	Commune No. 7	
1470	204	Commune No. 8	
1480	203	Commune No. 9	
1490	202	Commune No. 10	
1500	200	Free	

* Russia did not take part in the Washington Conference.

† The use of these waves, which are situated in a band not attached to Broadcasting by the Regulations added at the Washington Convention, is authorised with the express proviso that the stations which use them do not interfere with the services occupying this band.

In particular, it is necessary to ensure that the outputs from these stations do not render inoperative signals of distress, alarm, safety or urgency sent out on 500 Kc/s (600 m) and on 333 Kc/s (900 m).

In case of interference, the Administrations interested will endeavour to investigate every other suitable solution.

‡ The wavelength attached to Hungary will be brought back to the interior of the band attached exclusively to Radio Telegraphy on the first favourable occasion.

§ Exclusive wave kept in reserve in case there were mutual interference.

Note.—The Conference has noted the existence of the station of Kaunas (Lithuania), which has used different waves between 155 Kc/s (1935 m) and 151 Kc/s (1990 m) for a service of broadcasting. This station having interfered with the mobile services assigned to the station of Portishead (Great Britain) using the wave length 149 Kc/s (2013 m) and situated in the band kept exclusively for the mobile services, the Conference has asked the Administration of Great Britain to get in touch with that of Lithuania with a view to finding for the station of Kaunas a wavelength such that it may bring no interference to these mobile services.

A MACHINE TO DEMONSTRATE THE PROCESS OF MODULATING A CARRIER WAVE.

A. C. Timmis, B.Sc., A.M.I.E.E.

If the amplitude of a sine wave is varied according to a sinusoidal law at a lower frequency than that of the original carrier wave, it is said to be modulated, and the envelope of the modulated wave is sinusoidal. In the case of complete, or 100% modulation, the amplitude of the carrier varies from 0 to twice its normal amplitude. As the amplitude of the carrier wave is being changed continually, however, it ceases to be a true sine wave, and this distortion is exactly equivalent to the addition of the two sidebands. If a modulated wave be analysed into a Fourier series, it will be found to contain three frequencies: carrier, carrier + modulating frequency, and carrier − modulating frequency.

But the same result can fortunately be obtained by simple trigonometry—the analysis is given in the writer's article "Carrier Current Telephony" in the January, 1929, issue of this Journal.

If a carrier wave and the two sidebands be drawn in their correct relations of phase and magnitude and added together graphically or mechanically, the modulated wave will be synthesised. This addition can be very conveniently performed by means of a machine designed and made by the Marconi Company, in which the principle of Lord Kelvin's tide-predicting machine is employed.

The machine does not give a mechanical representation of what happens when modulation is carried out electrically, as, for instance, by varying the output of a carrier frequency oscillator in accordance with an audio frequency, and it occurred to the writer that a simple mechanical analogy to this process would be useful for instructional purposes, and as a complement to the Marconi synthesising machine.

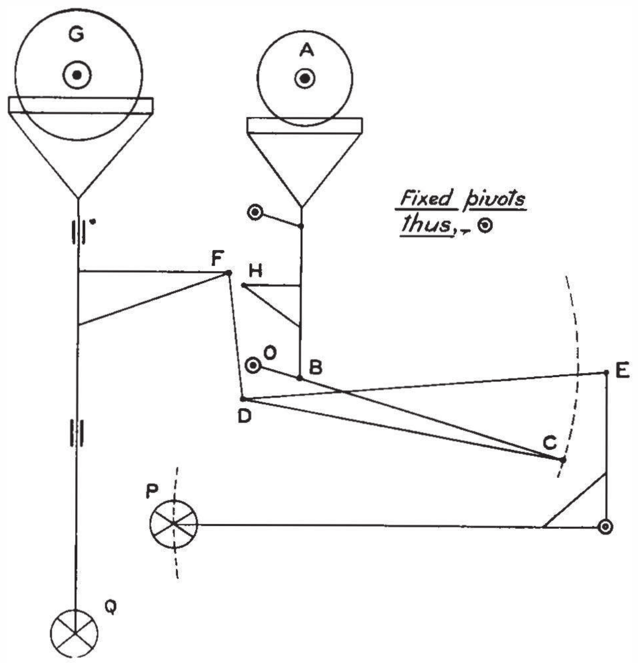


FIG. 1.

In Fig. **1** is shown the principle of a linkwork (designed originally as a multiplying mechanism for use in a measuring instrument) which enables the amplitude of a sine wave to be continuously varied in accordance with another motion. The crank and slot A impart—as regards vertical movement—a simple harmonic motion to the point B, on the link OC, which swings about the pivot O. The link CD is exactly the same length as OC. If the point F is fixed and OC swings through a fairly small angle the length OD is practically unchanged and may be regarded as one arm of a bell-crank lever BOD. The movement of D, which is transmitted to E and the pencil P, will therefore be a simple harmonic motion whose amplitude is proportional to the length OD, and whose frequency, which we will call the carrier frequency, is that of the crank A. Now suppose the length OD is made to vary from O to a maximum, by driving the point F from another simple harmonic motion whose frequency is determined by the crank and slot G. The amplitude of the motion of P will be proportional at any instant to the length OD which is proportional to the movement of F, and this is the condition for modulation of the " carrier " frequency of A by the " audio " frequency of G. The crank G may be geared, at various reduction ratios, and in any phase relation, to A.

In the actual machine, a view of which is given in Fig. **2**, ratios of 2 : 1, 4 : 1, 8 : 1 and 16 : 1 may be used between A and G by means of gear wheels. The paper is traversed under the pencils by means of rollers, seen on the right of the photograph, which can be driven at a convenient speed through the adjustable friction gear seen above the rollers. This gear is driven by the handle on the left of the photograph and the crank A (the carrier movement) is driven at the same time through bevel gears underneath the plate. The audio movement has a pencil (Q in Fig. **1**) which traces the audio wave, the lowest on the paper; and the carrier movement has a similar pencil on a swinging link which traces the middle curve. The top curve is the modulated wave.

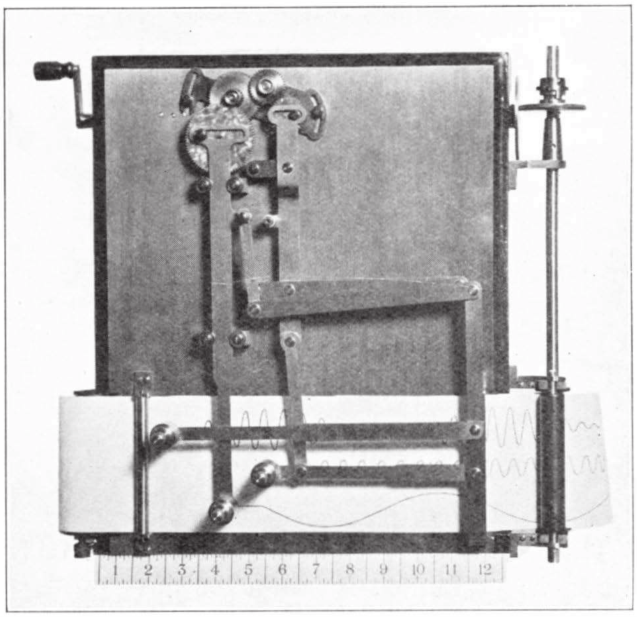


FIG. 2.

The link FD (Fig. **1**) is slotted so that its length can be adjusted to vary the degree of modulation within limits. It can also be swung over to a pivot on the carrier movement (H in

Fig. 1). The pencil P then traces the result of modulating a carrier wave by itself.

Applying the usual sideband formula to this case we obtain the carrier frequency, double that frequency, and zero frequency or DC. The result of this modulation is therefore the same as square law rectification, and the wave drawn by P is the partially rectified carrier wave. The point may perhaps be more clearly seen by considering only the carrier motion, with the link FD attached to H. The vertical motion of the point B may be represented by: $y = 1 + \sin \omega t$, where ω is the angular velocity of the crank. But the action of the linkwork is such that the movement of P represents the product of the movements of F and B; hence the movement of P may be represented by

$$\begin{aligned} y^1 &= (1 + \sin \omega t) \times y \\ &= (1 + \sin \omega t)^2 \\ &= 1 + 2 \sin \omega t + \sin^2 \omega t \\ &= 1\tfrac{1}{2} + 2 \sin \omega t - \tfrac{1}{2} \cos 2\omega t \\ &= \text{DC} + \text{carrier} + \text{second harmonic.} \end{aligned}$$

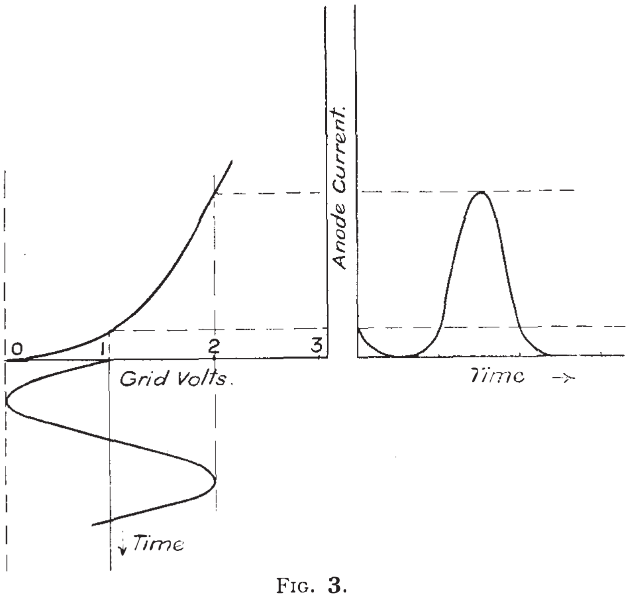


Fig. 3.

This is also the equation for square law rectification as performed by a valve whose grid is subjected to the sinusoidal voltage $1 + \sin \omega t$, measured from the bottom of the (parabolic) characteristic—Fig. **3**.

The anode current is obviously

$$y = kx^2 = \text{K}\,(1 + \sin \omega t)^2$$

If the priming point is made lower than 1 the grid voltage wave will cross the axis. In an actual valve the anode current would remain zero, but the parabola assumed in the equation would continue. The linkwork corresponds to the equation, and cannot therefore be used to illustrate a more complete degree of rectification than that shown in Fig. **3**.

The linkwork which forms the essential feature of the machine could be replaced by a dynamically equivalent set of cams, but link-work has the advantages that it is easy to make and practically frictionless. The slight error due to obliquity of certain links is of no consequence, seeing that the purpose of the machine is to demonstrate what happens during modulation. It is particularly interesting to generate a modulated wave in which the carrier is only a small multiple of the audio frequency, and to vary the phase relation between carrier and audio.

In this article the only system of modulation considered has been the straightforward one of which " anode choke modulation " is the usual form. There is another, quite apparently different, system, however. If two sine waves, a carrier and an audio frequency, for instance, are added together so that they heterodyne each other and are then passed through a square law rectifying device such as that of Fig. **3**, a complicated wave is produced which contains, among other things, the carrier and the two sidebands in correct phase relation, *i.e.*, the modulated carrier wave. The other frequencies may be filtered out, leaving the modulated carrier. There is evidently a close connection between the two systems of modulation, because the same mechanism performs modulation according to the first system, and square law rectification, which is the essence of the second system.

The latter type of modulation occurs more or less in any circuit where two frequencies are present and non-linearity is introduced by the presence of iron, as in the filter coils of carrier telephone systems. When modulation occurs thus, as an unwanted effect, it is sometimes called " cross-modulation." It is hardly practicable to design a mechanism to illustrate this type of modulation completely.

NOTES & COMMENTS

THE Council of the Institution of Electrical Engineers has nominated Colonel Sir Thomas F. Purves, Engineer-in-Chief of the Post Office, to be President of the Institution for the forthcoming year. For the second time this year we have to offer our congratulations to the head of the engineering department upon an honour conferred. The position of president of the I.E.E. is no sinecure—it is rather in the nature of a whole time job, but, in spite of the heavy work of his own department, we feel certain that the new president will sustain worthily the prestige of the office, created and borne so successfully by the line of distinguished predecessors.

Mr. W. A. Valentine has retired on age limit from the post of Controller of the London Telephone Service, and has been succeeded by the Deputy Controller, Mr. W. H. U. Napier. Mr. Valentine has had a strenuous career, with the N.T. Coy. and for the past seventeen years with the P.O., and his many friends trust he will remain in good health to enjoy the rest he has so deservedly earned.

Speaking in the Newfoundland Legislative Assembly on 17th April, Sir R. A. Squires, the Premier, announced his intention of introducing a Bill during the present session to empower the American Telephone and Telegraph Co. to lay new Transatlantic cables, *via* Newfoundland, for telephone purposes between the two hemispheres. The cable, it is understood by Reuters, will be laid from America into Placent Bay, carried across the isthmus to Conception Bay and thence to Europe. It is understood that the European end of the cable will be landed in Ireland.

Messrs. Siemens Bros. have just completed and at the time of writing are engaged in laying a continuously loaded cable from England to the Isle of Man, and two cables from the island to Northern Ireland. In our next issue we hope to be able to give a detailed technical description of the construction and characteristics of these cables, which will provide a trunk service to the island and improve communication with Ireland.

The A.T.M. Coy. have sent us a copy of their pamphlet on "The A.T.M.-Doignon Multiplex Printing Telegraph System," which explains very fully, and with finely executed illustrations, the details of the system. The improvements claimed over the existing Baudot multiplex are as follows:—(1) The suppression of the Baudot governor. (2) Suppression of the moderator on receiver. (3) The use of a commercial type motor to drive the distributor with constant speed. (4) Automatic control of receiver speed and phase. (5) Alteration of distributor and receiver speeds, by simply turning one adjusting screw. (6) Suppression of all gear trains in the receiver units. As a result of the last mentioned, the keyboard can be mounted in the base of the receiver and readily locked and unlocked. An independent keyboard with cadence and lock can be fitted, if necessary. A description of the distributor governor is given, as well as a mathematical treatment of its action.

TELEGRAPH OR 'PHONE?

If the Rotarians, at their luncheon to-day, expected Mr. T. E. Herbert, of the Post Office engineering department, to answer some of the criticisms made against the Post Office, they were disappointed. He addressed himself wholly to the question whether the telegraph system will be superseded by the telephone. About this he was, as he remarked, an " incurable optimist " on the side of the telegraph, despite the fact that the system is being run at a loss of £1,500,000 a year. That does not necessarily say, though, that the telegraph is in a state of honourable yet inevitable decay. For Mr. Herbert believes that the system should be carrying a reasonable amount of the traffic which at present goes by mail. As he remarked, speeding up business increases profits, and it ought to pay the nation to expand the telegraph system by giving a cheaper, better, and quicker service.

Mr. Herbert incidentally brought forward one rather interesting criticism of the telephone. The telephone is obviously a blessing in many ways, but there are other times when it becomes extremely irritating. How many minutes are wasted every day by trivial inquiries? The delays due to these, at least, could be prevented by a greater use of the telegraphic service.

—*Manchester Guardian,* 12th April, 1929.

The Bell Telephone Quarterly for April gives the concluding part of an important article by H. S. Osborne on " Standardisation in the Bell System."

In concluding the article Mr. Osborne says this general outline of standardizing activities in the Bell System is sufficient to indicate the outstanding part which standardization has played in the building up of the Bell System. For many years, standardization based upon not only the present needs of the telephone system but also the best picture obtainable of future trends, has been an integral part of the programme of development of telephone service. One type of standardization increases both the possibility and the advantages of another type so that in such an organisation, standardization activities ramify through the entire structure and touch every part of the work.

The total economies resulting from standardization, of course, it would be impossible to closely estimate. Standardization as indicated above, has been productive of many advantages in addition to economy. The advantages from standardization may be summarized as follows:

1. Standardization makes the best available for all.
2. Standardization reduces the cost because, when all companies use the same things, they can be manufactured in the largest quantities and uniformity in output contributes to economies in production.
3. Standardization reduces the cost of carrying stocks of materials and the cost of maintenance and repairs, because fewer parts have to be carried and maintained.
4. Standardization reduces the cost of instruction of new employees because there are fewer things with which to get acquainted.
5. Standardization reduces accounting costs because there are fewer types and sizes of materials to keep track of.
6. Standardization minimizes complicated engineering and operating problems that might result from intercommunication between widely divergent systems and apparatus.
7. Standardization renders available large supplies of materials and labour in emergencies.
8. Standardization greatly facilitates development work, since improvement in, or development of, a new article involves a co-ordination with a smaller number of associated parts.

C.B. CLAY FOOTBALL CHALLENGE CUP.

The final tie in the C.B. Clay Challenge Cup was played on the Tufnell Park Football Ground on Tuesday evening, 16th April, between teams from the Post Office Stores Department (Holloway) and the Engineer-in-Chief's Office. The latter team won by five goals to three after extra time had been played. Col. C. B. Clay, the donor of the Cup, was unfortunately unable to be present owing to an attack of ptomaine poisoning, and in his absence the presentation of the cup, together with miniature cups to each member of the winning team, was made by Mr. H. Sparks, O.B.E., the Controller of Stores. Mr. Sparks paid a tribute to both teams for the excellent game they had played and also said he was sure all present would wish Col. Clay a speedy return to good health. It may interest readers of the Journal to know that this Football Challenge Cup was first instituted in 1898 and is still open to all teams representing the staff of any branch or section of the Post Office associated with the Telephone Service in London including the following departments :—

The Secretary's Office.
The London Telephone Service.
The Post Office Stores Department.
The London Engineering District.
The Office of the Engineer-in-Chief.

Entries for the competition are cordially invited and particulars can be obtained from the Hon. Secretary, Mr. C. J. Head (London Engineering District), Mr. A. E. Wild (London Telephone Service), or Mr. F. Woollard (Engineer-in-Chief's Office). The proceeds of all matches are devoted entirely to charity and the competition has been the means of raising over £200 during the past two or three years.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed :—

Exchange.	Type.	No. of Lines.
Gladstone (Advance portion) ...	New Auto.	M.D.F.
Linthorpe	,,	560
Marine (Southend)	,,	1430
Nottingham	,,	7255
Southbank	,,	185
Stockton	,,	1280
Temple Bar	,,	7900
Cwmbran	Auto Extn.	130
Leeds	,,	Modfns.
Newport	,,	400
Tandem	,,	Positions
Ashford	New Manual	500
Berkhampstead	,,	580
Deal	,,	860
Stanmore (Advance portion) ...	,,	M.D.F.
Upminster	,,	440
Bournemouth	Manual Ext.	680
West Bromwich	,,	420
Cardiff Corporation	P.A.B.X.	
Consett Iron Co.	,,	20
East African Society	,,	
Hazell Watson & Viney ...	,,	30
Shell Mex (Southampton) ...	,,	30
Taylor & Parsons	,,	30
Universal Grinding Wheel ...	,,	20
Uxbridge Guardians	,,	20
Woolwich Guardians	,,	20

Orders have been placed for the following works :—

Exchange.	Type.	No. of Lines.
Arnold	New Auto.	450
Beeston	,,	730
Bulwell	,,	540
Carlton	,,	635
Gladstone	,,	4860
Hampstead	,,	6666
Leytonstone	,,	2470
Pollards	,,	4000
Arkwright	Auto Extn.	760
Epsom	,,	300
Foleshill	,,	100
Grimsby	,,	530
Nottingham	,,	190
Sheffield Area Coin Box Equipt.	,,	—
Sherwood	,,	190
Sketty	,,	340
Hastings	New Manual	3410
Romford	,,	1780
Theydon Bois	,,	270
Crosly	Manual Ext.	900
East Grinstead	,,	240
Jesmond	,,	600
Consett Iron Co.	P.A.B.X.	20
East London Rubber Co. ...	,,	50
Hazell Watson & Viney ...	,,	30
Kent Education	,,	30
Preston Corporation	,,	30
Stalybridge Corporation ...	,,	20
Synthetic Ammonia	,,	100
Taylor & Parsons	,,	30
Woolwich Guardians	,,	20
Yarmouth Corporation ...	,,	30

LONDON DISTRICT NOTES.

Telephones.—The following figures show the changes in the number of exchange lines, extensions, and stations during the three months ending and the totals at 31st March, 1929 :—

	Increase.	Total.
Exchange Lines ...	7,733	363,226
Extensions ...	7,243	308,596
Stations	13,274	611,588

External Plant.—During the same period the changes shown below have occurred in mileage :

Telegraphs.—A nett decrease in open wire of 2 miles and a nett increase of 164 miles in underground.

Telephones (Exchange).—A nett increase of 255 miles in open wire and nett increase of 40,734 miles in underground.

Telephones (Trunk).—A nett increase of 10 miles in open wire and nett increase of 2,268 miles in underground.

Pole Line.—A nett increase of 13 miles, the total to date being 5,908 miles.

Pipe Line.—A nett increase of 169 miles, the total to date being 10,429 miles.

The total single wire mileages at the end of the period under review were :—

Telegraphs	26,147
Telephones (Exchange) ...	2,497,551
Telephones (Trunk) ...	80,377
Spares	119,122

TELEPHONE EXCHANGE PROGRESS.

Manual.—Upminster C.B. No. 1 was opened on the 11th April equipped with 720 lines.

Automatic.—It is anticipated that the following Exchanges will open during the next three months :—

Exchange.	No. of Equipped Lines.	Manufacturer.
Beckenham	3,000	Siemens
Reliance	2,700	General Electric Co.
Maida Vale	7,500	Siemens
Edgware	1,300	General Electric Co.
Metropolitan	9,500	A.T.M.
National	9,500	A.T.M.
Fulham	7,500	Standard
Flaxman (Kensington)	9,900	General Electric Co.
Mitcham	1,480	Siemens
Hendon	4,200	A.T.M.

CALL OFFICES.

The work of converting Call Offices from Post Payment to Pre-Payment working is proceeding throughout the District. Arrangements are also being made to fit emergency calling apparatus in Kiosks.

The first of the new iron kiosks (No. 4) has now been erected in Euston Road, opposite Kings Cross Station. It is a post office in miniature combining as it does a telephone call office, with all the usual facilities, a letter box, and a stamp vending machine. These latter are placed on the outside at the back so that the sale of stamps and posting of letters does not interfere with the use of the telephone. The all-embracing nature of the facilities is shown by the various opal signs worded " Telephone," " Post Office " and " Stamps." The kiosk is very similar in design to the ordinary iron kiosk.

A new type of concrete kiosk (No. 3) to the design of Sir Giles Gilbert Scott, is now making its appearance in various parts of London.

The design corresponds somewhat with that of the familiar iron kiosk, but whereas this is coloured red the concrete kiosk is coloured cream, with the glazed frames picked out in red. The glazed portions extend much lower than in the original type of concrete kiosk (No. 1) and four opal signs are provided just below the domed roof. The structure is 8′ 7½″ in height by 3′ 1″ square overall and presents a very pleasing appearance.

CALL OFFICE CABINETS.

A suite of eleven oak cabinets has replaced standard cabinets at the Arcade, Liverpool Street; the attendance booth has been abolished and multiple coin boxes have been introduced.

A suite of cabinets, in teak, has been installed at Charing Cross Station.

EPSOM AUTOMATIC EXCHANGE.

This exchange, which is the oldest public automatic exchange in the country, was installed in an adapted dwelling house at Epsom in the year 1912. When the growth of lines necessitated more space for automatic switches arrangements were made for the manual portion of the Epsom traffic to be dealt with at Sutton. The growth of lines at Sutton, however, outgrew the available accommodation and, pending the construction of a new exchange at Sutton, it was necessary to transfer the Epsom Manual work to Streatham. The new Sutton exchange has now been opened and the 107 circuits which carry the manual traffic of the Epsom area have been transferred thereto.

TRANSFERS OF SUBSCRIBERS' LINES.

The establishment of additional exchanges in a multi-exchange area necessarily involves the transfer of a number of existing subscribers' lines from one exchange to another. It is probable that very few persons, apart from those engaged in organising the transfers, realise the magnitude of these operations in the London area. For example, in March, 1929, over 17,000 lines were transferred and arrangements are being made for the transfer of 18,200 lines in September. It is probable that a similar number will be transferred at each Directory issue for the next two or three years. It is needless perhaps to say that subscribers dislike to be given a change of exchange name and number and their reasons for this dislike are appreciated. Every effort is therefore made to reduce the inconvenience to a minimum. When investigations are being made to determine how relief can best be given to an exchange which is approaching the limit of its capacity the necessity to cause as little disturbance as possible to existing subscribers is a prominent consideration. Nevertheless, just as it is impossible to make an omelette without breaking eggs, so it is impossible to make a satisfactory lay-out in a growing telephone system without breaking up the existing groups of subscribers which form exchange areas and forming fresh groups in which there is room for expansion. The only alternative would be one so expensive as to be altogether impracticable. It would involve an estimate of the magnitude and distribution of the subscribers' lines for several decades which would have to be more accurate than is at present considered practicable in this or any other country, a statement of what the calling rate would be and the community of interest between the various areas, and also a lifting of the veil to indicate what improvements in apparatus and cable will take place. Buildings of suitable size and with the right type of apparatus might then be provided at once in all the areas which it may ultimately be necessary to form, to which would be connected all lines in those areas. It will be readily grasped that during the earlier years many of the buildings would have very few lines connected to them and the ratio of the expenditure due to the annual charges on buildings, equipment and line plant, and the cost of operating, to the income from subscribers' rentals and fees would be exceedingly high. If the service is to be kept self-supporting such a policy would involve the raising of fees to subscribers in order to compensate for the increased expenditure, and although this might not kill the goose that lays the golden eggs, it would probably put it off its feed and thus reduce its laying capacity.

The necessity for transfers must therefore be faced, and the fact that such large blocks are transferred with so little inconvenience to the subscribers indicates how carefully those officers of the Traffic and Engineering Departments who are directly concerned work out the details of what is necessarily a very intricate piece of organisation. A tribute must also be paid to those telephonists whose duty it is to divert calls to the new channels and smooth over the irritation which is felt by the transferred subscribers during the first few weeks after the transfer. Notwithstanding the magnitude of the transfers the complaints are remarkably few.

EMERGENCY CHARGING SETS FOR TELEPHONE EXCHANGES.

A portable Emergency Charging Set mounted on a trailer and operated by a 4 Cylinder Crude Oil Deisel Engine is being tried experimentally in the L.E.D. The rated output of the machine is 1,000 amperes at 60 volts. The complete unit weighs approximately 8 tons, and is transported by means of a tractor.

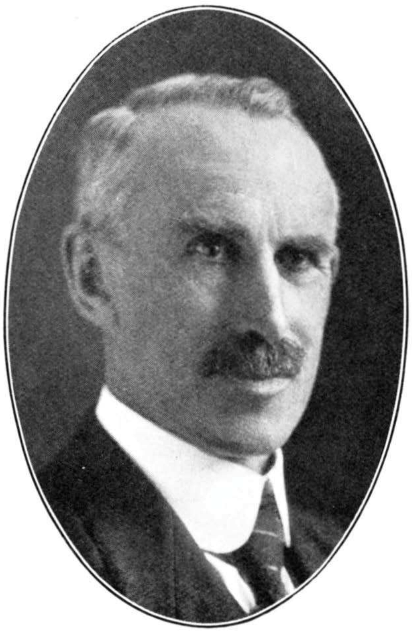
TELEGRAPHS.

One of the Multiplex telegraph sets has been superseded by Teleprinters with voice frequency transmission.

A double duplex Baudot set has been installed on a Berlin circuit for experimental purposes.

At certain racing centres near London, Teleprinters have been introduced to replace Wheatstone apparatus and the change is regarded as a considerable improvement. Unfortunately, however, the majority of Race-course Grand-stands have no motive power facilities for driving the Teleprinters, and the cartage of batteries is thus involved. The matter is being investigated with a view to minimizing the inconvenience thus caused.

RETIREMENT OF MR. R. McILROY, I.S.O.



ROBERT McILROY, I.S.O.
Late Superintending Engineer, London Engineering District.

ROBERT McILROY entered the service of the Post Office at Belfast where he was appointed as Telegraphist on 6th July, 1885; and for six years he was an apt pupil in a school of experience which, though it awarded no diplomas, was very successful—if the metaphor may be permitted—in sifting grain from chaff. Mr. McIlroy can recount many amusing episodes of that period, including some relating to happenings whilst "on hire" to Railway Companies for whom the Post Office provided Telegraphists; but the number of those episodes was restricted by the sifting process, which transferred him to the Engineering Department as a Junior Clerk in 1891, and thence early in 1893 to the Engineer-in-Chief's Office in the capacity of Draughtsman and Shorthand Writer.

It was not long before Mr. McIlroy's obvious abilities led to his selection for the post of personal assistant to the late Mr. James Hookey, then Assistant Engineer-in-Chief, and subsequently Engineer-in-Chief, which post he filled with conspicuous success until Mr. Hookey's retirement in 1902: during those years he carried a load of administrative work to which, whether judged from the standpoint of variety or of magnitude, there have been few parallels in the history of the Post Office Engineering Department.

In September, 1907, he was appointed to a Staff Engineership, First Class, and took charge of the Section of the Head Office which had been formed to deal with all matters concerning the construction of external plant and the protection of plant from power circuits, and also the scrutiny of all works estimates; and in April, 1909, he succeeded the late Mr. W. Vyle as Superintending Engineer of the South Wales District with headquarters at Cardiff, where he remained for 12 years.

On 1st August, 1921, at the age of 52, Mr. McIlroy was promoted to the Superintending Engineership of the London Engineering District, and in that position found full scope for a rare combination of administrative ability and practical experience. Under the most favourable conditions the headship of the London Engineering District, with a rapidly expanding staff which now numbers more than 8,000, would be a severe test of quality; and the briefest consideration of the numerous problems arising out of post-war conditions, supplemented by those incidental to engineering development, including the adoption of the "Director" system of automatic telephones, will furnish some idea of the responsibility of the position during the past 8 years. It would have been no small achievement merely to have maintained the efficiency of the District:

Mr. McIlroy may claim much more than this without fear of question. He will be remembered as one who led his staff by trusting them and who, in everything he undertook, set them the example of producing a finished piece of work.

So much for the official aspect of Mr. McIlroy's career; what of the man behind the official? Those who have been privileged to know the man have found a strong straightforward and, in many respects, unconventional character, to which a keen sense of justice and a deep sympathy for those in trouble and misfortune make equal contributions: many paths have been smoothed by the kindly insight of the man, and very often the travellers have not known either the extent or the direction of their indebtedness.

Mr. McIlroy has earned his leisure: may he and Mrs. McIlroy long be spared to enjoy it together. J.W.A.

POST OFFICE ENGINEERING AND STORES DEPARTMENTAL WHITLEY COUNCIL.

REPORT OF COMMITTEE ON RECRUITMENT.

MEMBERSHIP.

THE Committee on Recruitment was reconstituted in July, 1928, to review the Recruitment Scheme, and the following were appointed to it:—

Official Side—

Mr. E. Raven, C.B. *(Chairman)*.
Col. Sir T. F. Purves.
Mr. E. H. Shaughnessy.
Mr. W. H. Weightman.
Dr. R. V. Hansford *(Secretary)*.

Staff Side—

Mr. E. H. Williams *(Vice-Chairman)*.
Mr. F. Edwards.
Mr. A. Grierson.
Mr. G. E. Harding.
Mr. T. Hargreaves.
Mr. L. S. Summers.
Mr. G. Balchin *(Secretary)*.

Mr. C. H. Smith acted as Vice-Chairman for the first meeting only. The Committee has held seven meetings.

At the first meeting the Official Side pointed out that a review of the Recruitment Scheme for Assistant Engineerships and Inspectorships was considerably overdue, and that the matter had been brought to a head by the Report of the Leech Committee on Engineering Organisation, which expressed the definite opinions that there should be a considerable reduction in the percentage of Assistant Engineerships filled by promotion and that there should be a substantial increase in the percentage of Inspectors recruited by the Limited Competition. These opinions had been accepted by the Department; the Official Side must therefore be regarded as approaching the matter from this point of view. Other aspects of the Recruitment Scheme to be discussed were the age limits for the Competitions, the eligibility of certain classes for appointment to Engineering posts, and the re-institution of a " Certificate Qualification " as a condition of promotion to the rank of Inspector.

The recommendations of the Committee in regard to these questions and certain minor modifications to the existing Recruitment Scheme are detailed in this Report. An Appendix is attached which summarises the proposed conditions of recruitment.

PERCENTAGE OF VACANCIES TO BE FILLED BY COMPETITION.

The Official Side stated that it was considered that the present scheme needed modification for two main reasons. In the first place, the ages at which men are promoted to Assistant Engineerships under the ordinary procedure are so high as to make it a matter of serious difficulty to find an adequate supply of Engineers of suitable age for the higher controlling posts. A substantial lowering of the promotion age is hardly to be expected; there is therefore good ground for advancing more men to the Assistant Engineer grade by means of the Competitions, so as to reduce the average age of the grade.

In the second place, it is the view of the controlling officers of the Engineering Department that candidates from the Competitions possess, on the average, greater potentialities for further advancement than men promoted through the ordinary procedure; and that from this point of view also there is a strong argument for extending the scope of the Competitions.

In the opinion of the Official Side, the only alternative to an increase in the proportion of posts to be filled by competition would be a very much more drastic selection of junior men for promotion; apart from the great difficulty attendink the selection, the Official Side would expect to find that such a procedure would produce a more acute sense of grievance than if the posts were filled by competition. The Staff Side admitted the force of the latter contention, but stated that the immediate adoption of drastic alterations to the present scheme of percentages must necessarily react unfavourably on the interests of the members of the existing classes and would unduly favour youth as compared with age and experience. The Staff Side also contended that even if changes were necessary in the methods of obtaining recruits every effort should be made to get them from within the Department.

After considerable discussion the Committee agreed to recommend an increase in the percentages of vacancies allocated to the Limited Competitions, but, in order to conserve the interests of the existing personnel as far as possible, it proposes that the changes should be made in three stages of two years each. Accordingly it recommends that the vacancies be allocated as indicated in the following table for an experimental period of six years, and that the question be reviewed at the end of that period :—

	1928	1929-30	1931-2	1933-4
Assistant Engineers :				
Open Competition ...	20	20	20	20
Limited Competition ...	20	25	30	40
Promotion	60	55	50	40
Inspectors :				
Open Competition ...	10	10	10	10
Limited Competition ...	10	20	30	40
Promotion	80	70	60	50

The Committee recommends that shortages in any one source of supply should be made good from the other sources. Any departure from these percentages which is found to be necessary should be the subject of prior discussion on the Departmental Whitley Council.

Age Limits for Competitions.

Experience has shown that the upper age limits for the Open Competitions are somewhat low and tend to debar suitable candidates who have not completed their course of study while still within the age limits.

Under the terms of the previous Reports an upper age limit for both the Limited Competitions of 40 years was recommended for a limited number of years, after which the upper age limits for Assistant Engineers and Inspectors were to be 30 and 25 years respectively. The reduced upper limits of age have not been brought into force, pending the review of the scheme.

The Committee considers that the upper age limits for the various Competitions might with advantage be somewhat higher than the final limits recommended in the Fourth Report and recommends that the following age limits for the Competitions be brought into operation forthwith :—

(1) *Assistant Engineers.*
  (*a*) Open Competition—20 to 25, with 2 years' extension for approved Works experience.
  (*b*) Limited Competition—23 to 32.

(2) *Inspectors.*
  (*a*) Open Competition—17 to 23.
  (*b*) Limited Competition—20 to 30.

Reinstatement of Technical Certificates as a Condition of Eligibility for Promotion to Inspectorships.

The Official Side stated that in view of the advances in complexity and technique of the work of the Engineering Department, and of the increased facilities now available for technical education, it was considered not unreasonable to revert to the pre-war practice of making the possession of technical certificates one of the recognised normal qualifications for promotion to the supervising grade of Inspector. In the absence of certificates there should be some other countervailing qualifications of a special order. The Official Side therefore proposed that an officer promoted to the rank of Inspector should be required to possess, as a minimum, certificates equivalent to those which are at present recognised as a qualification for a full technical allowance to workmen. The Official Side, however, did not suggest that every candidate for promotion should possess certificates in *both* Telegraphy and Telephony, if a higher certificate is obtained in one subject only.

The Staff Side did not challenge the contention of the Official Side, provided that the reinstitution of the "Certificate Qualification" was coupled with reservations in favour of the existing staff, who had acted on the assumption that there would be no change in the present Regulations.

The Committee accordingly recommends that a "Certificate Qualification" should be instituted forthwith as one of the normal qualifications for promotion to the rank of Inspector. The Certificates recognised should be those issued by the City and Guilds of London Institute, and the requisite qualifications should be as follows:—

A First-Class Certificate in Magnetism and Electricity, together with one of the following alternatives:—

(1) Certificates in two of the subjects Telephony, Telegraphy, and Radio Communication, which should be either a First Class in the Ordinary Grade or a Second Class in Grade II. or the Final Grade in each case.

(2) One certificate in Telephony, Telegraphy, or Radio Communication, which should be a First Class in Grade II. or the Final Grade.

The Committee also recommends that the possession of these prescribed certificates should not be an essential condition for promotion in the following cases:—

(*a*) Officers born before the 1st January, 1894.

(*b*) Officers of the grades normally eligible for direct promotion to the rank of Inspector who "qualified" in either a Limited or an Open Competition for Inspectorships but did not obtain an appointment.

(*c*) Officers who have countervailing qualifications of a special order.

LIMITED COMPETITION FOR INSPECTORSHIPS. SYLLABUS OF EXAMINATION.

The Committee recommends that a subject entitled "Radio Communication" should be included as an optional subject in the Limited Competition for Inspectorships.

ELIGIBILITY OF DRAUGHTSMEN FOR PROMOTION TO RANK OF INSPECTOR.

While Draughtsmen are not regarded as in the normal line of promotion to Inspectorships, the Committee recommends that they should be eligible for exceptional promotion to that rank if they possess the necessary practical and technical qualifications.

ELIGIBILITY OF CLERICAL STAFF FOR AN INCREASED OUTLET TO SUPERVISING ENGINEERING GRADES.

The Committee discussed this question with the Staff Side of the Clerical Committee of the Departmental Whitley Council and has given careful consideration to the suggestions made by the Staff Side of the Clerical Committee.

These suggestions were to the effect that Clerks in the Engineering Department should be eligible for nomination to probationary posts as Assistant Engineers and Chief Inspectors, the necessary training being given during the probationary period. At the end of the period the appointment to the engineering grade would be confirmed if a certificate of efficiency could be given: otherwise the officer would revert to his clerical post.

After careful consideration the Committee is unable to recommend this plan for adoption. Under the present scheme of organisation, Assistant Engineers are normally employed either as second in command of an Engineering Section, or upon high-grade technical work at Headquarters or in the District Technical Sections. The Committee does not consider that clerical work in the Engineering Department would be likely to fit a man to fill either of these types of posts, even after a probationary period.

As regards Chief Inspectorships, the primary function of this grade is the control of groups of Inspectors, who in their turn are in control of large bodies of workmen. In the opinion of the

Committee the performance of clerical duties is not a suitable preparation for work of this nature.

The Committee is therefore of the opinion that it would not be in the interests of the Engineering Department that Clerical Classes should be granted an avenue of advance either to Assistant Engineerships or to Chief Inspectorships. The Clerical Classes are already eligible to compete in the Limited Competition for Inspectors; and the facilities for Clerks to become Inspectors will be substantially increased by the proposed increase from 10 per cent. to 40 per cent. in the percentage of appointments allocated to the Limited Competition and by the extension of the age limit.

The Committee recognise the stagnation of promotion which exists on the clerical side of the Engineering Department and would have been glad if it could have recommended measures which would relieve this stagnation; but in view of the growing complexity of engineering work, and the urgent importance of maintaining a high standard of efficiency, it does not feel able to recommend the admission of Clerks to grades above that of Inspector.

Eligibility of Assistant Traffic Superintendents for an Increased Outlet to the Supervising Engineering Grades.

The Committee discussed with a representative of the Association of Assistant Traffic Superintendents (Provinces) the question of providing an increased outlet for Traffic Officers to the Supervising Engineering grades.

The Committee recommends that Assistant Traffic Superintendents who are otherwise eligible, or who, after three years' approved service in the Traffic Branch, receive a nomination by the Engineer-in-Chief, to compete at the Open Competition for Assistant Engineerships should be granted an extension of age in respect of the period employed on traffic work in the Post Office, plus any period claimable in respect of engineering works experience, up to a maximum of five years.

The Committee is unable to recommend the admission of Assistant Traffic Superintendents to the Limited Competition for Assistant Engineerships.

12st March, 1929.

APPENDIX TO REPORT OF COMMITTEE ON RECRUITMENT.

Summary of Conditions of Recruitment of Assistant Engineers, Chief Inspectors, and Inspectors.

I.—PERCENTAGE ALLOCATION OF VACANCIES

(i) *Assistant Engineerships*

Method of Recruitment.	Year			
	1928	1929-30	1931-32	1933-34
Open Competition	20	20	20	20
Limited Competition	20	25	30	40
Promotion	60	55	50	40

(ii) *Chief Inspectorships*

Method of Recruitment.	
Promotion	100

(ii) *Inspectorships*

Method of Recruitment.	Year			
	1928	1929-30	1931-32	193-34
Open Competition	10	10	10	10
Limited Competition	10	20	30	40
Promotion	80	70	60	50

NOTE.—Shortages in any one source of supply to be made good from the other sources, subject to discussion on the Post Office Engineering and Stores Deparmental Whitley Council.

II.—GRADES ELIGIBLE

(i) *Assistant Engineerships*

Open Competition	Limited Competition	Promotion.
(*a*) Graduates in Engineering who have taken complete engineering course. (*b*) Whitworth Scholars. (*c*) Holders of Diploma of Membership of Imperial College in Physics or Engineering, or Diploma of Associateship of City and Guilds Institute; or in exceptional cases, others who satisfy Civil Service Commissioners in regard to training and qualifications. (*d*) P.O. employees nominated by the Engineer-in-Chief.	(*a*) Chief Inspectors, Inspectors Repeater Officers with 3 years' approved Post Office Service at the date fixed for the examination. (*b*) Draughtsmen, Wayleave Officers, Skilled Workmen with 5 years' approved service in the Engineering Department at the date fixed for the examination. All candidates to be nominated by the Engineer-in-Chief.	Chief Inspectors. Inspectors. Repeater Officers.

(ii) *Chief Inspectorships*

By promotion from—

(*a*) Inspectors (*b*) Repeater Officers (*c*) Draughtsmen	in exceptional circumstances.

(iii) *Inspectorships*

Open Competition	Limited Competition	Promotion.
No restrictions.	(*a*) Clerks, Draughtsmen, Wayleave Officers, and Skilled Workmen in the Engineering Department. (*b*) Telegraphists (including Wireless Telegraphists), Sorting Clerks and Telegraphists with manipulative ability. All candidates to have five years' approved Post Office service at the date fixed for the examination and to be nominated by the Engineer-in-Chief.	Skilled Workmen, Draughtsmen (in exceptional circumstances). Subject to Certificate Qualification. (See VI).

III.—AGE LIMITS FOR COMPETITIONS

Assistant Engineerships		Inspectorships	
Open Competition	Limited Competition	Open Competition	Limited Competition
20 to 25 with extension as stated below.	23 to 32	17 to 23	20 to 30

Note.—The following extensions of age are permitted to candidates in the Open Competition for Assistant Engineerships:—

(*a*) Two years' extension for practical experience in approved Engineering Works.

(*b*) Assistant Traffic Superintendents who are otherwise eligible, or who, after three years' approved service in the Traffic Branch receive a nomination by the Engineer-in-Chief, may be granted an extension in respect of the period employed on traffic work in the Post Office, plus any period claimable under (*a*) up to a maximum of five years.

IV.—SYLLABUSES FOR COMPETITIONS.

(A) Open Competition for Post Office Assistant Engineerships.

Subjects of Examination

(1) Mathematics (2) Electro-Technology (3) Materials (4) Theory of Machines	Compulsory. Candidates must " pass " in all these subjects.
(5) Personal Qualities	
(6) Alternating Currents (7) Electrical Machines (8) Heat Engines (9) Telegraphy and Telephony	One subject to be taken.

Note. The subjects have been chosen with the object of providing a syllabus suitable without additional training for Engineering graduates of any of the principal Universities. The detailed syllabus for each subject, the grade of marking and the " pass " standard will be specified by the Civil Service Commissioners.

After the examination, personal qualities (Subject 5) will be judged by an Advisory Board and the marks awarded will be added to the examination totals.

(B) Limited Competition for Post Office Assistant Engineerships.

Subjects of Examination

(1) Mathematics (2) Electro-Technology (3) Elementary Materials and Structures	Compulsory. Candidates must " pass " in all these subjects.
(4) Personal Qualities	
(5) Telegraphy and Telephony (6) Physics (*a*) (7) Chemistry (*a*)	Two subjects only to be taken.

Note.—The detailed syllabus for each subject, the grade of marking and the " pass " standard will be specified by the Civil Service Commissioners, the standard for the subjects marked (*a*) being appropriate to intermediate University examinations.

After the examination, personal qualities (Subject 4) will be judged by an Advisory Board and the marks awarded will be added to the examination totals.

(C) Open Competition for Post Office Engineering Inspectorships

Subjects of Examination

(1) Pure Mathematics (2) Applied ,, (3) Electricity and Heat (4) Engineering Drawing and Design	Compulsory. Candidates must " pass " in all these subjects.
(5) Personal Qualities	
(6) Sound and Optics (7) Chemistry (8) Telegraphy and Telephony	One of these subjects only to be taken.

Note.—The detailed syllabus for each subject, the grade of marking and the " pass " standard will be specified by the Civil Service Commissioners.

After the examination, personal qualities (Subject 5) will be judged by an Advisory Board and the marks awarded will be added to the examination totals.

(D) LIMITED COMPETITION FOR POST OFFICE ENGINEERING INSPECTORSHIPS

Subjects of Examination

(1) Pure Mathematics (2) Applied Mathematics (3) Electricity and Heat (4) Engineering Drawing and Design	Compulsory. Candidates must " pass " in all these subjects.
(5) Personal Qualities	
(6) Telegraphy (7) Telephony (8) Radio-Communication (9) Sound and Optics (10) Chemistry	One of these subjects only to be taken.

NOTE.—The detailed syllabus for each subject, the grade of marking and the " pass " standard will be specified by the Civil Service Commissioners.

After the examination, personal qualities (Subject 5) will be judged by an Advisory Board and the marks awarded will be added to the examination totals.

V.—PROBATIONARY SERVICE AND SCALE OF PAY

Probationers selected through any examination will be paid a salary commencing at least two and not more than four incremental points below the minimum of the Assistant Engineers' or Inspectors' scale and will normally serve as probationers for two years with tests at six monthly intervals; they will be appointed Assistant Engineers or Inspectors respectively normally after two years' satisfactory probationary service, but probationers certified to possess adequate qualifications and practical experience may be appointed to the substantive rank before the end of two years when so certified, seniority in that rank counting from the date of this certificate. (Appointment is in every case subject to not less than twelve months' probation).

VI.—" CERTIFCATE QUALIFICATION " FOR INSPECTORSHIPS

A recognised normal qualification for promotion to Inspectorships is the possession of technical certificates issued by the City and Guilds of London Institute. The required certificates are as follows :—

A First-Class Certificate in Magnetism and Electricity, together with one of the following alternatives :—

(1) Certificates in two of the subjects Telephony, Telegraphy and Radio Communication which should be either a First Class in the Ordinary Grade or a Second Class in Grade II of the Final Grade in each case.

(2) One Certificate in Telephony, Telegraphy or Radio Communication which should be a First Class in Grade II or the Final Grade.

The possession of these certificates is not an essential condition for promotion in the following cases :—

(*a*) Officers born before 1st January, 1894.

(*b*) Officers of the grades normally eligible for direct promotion to the rank of Inspector who " qualified " in either a Limited or an Open Competition for Inspectorships but did not obtain an appointment.

(*c*) Officers who have countervailing qualifications of a special order.

TELEPHONE FINANCE AND STATISTICS OF THE AMERICAN BELL CO. AND THE BRITISH POST OFFICE.

W. J. Medlyn, M.I.E.E.

An article on the growth and finance of the British Telephone Service was published in the *P.O.E.E. Journal*, Volume 13, Part 2, in July, 1920, and a further article on the same subject appeared in Volume 18, Part 3, issued in October, 1925. A brief note on the Post Office Commercial Accounts for the year ending 31st March, 1928, was published in this Journal in April last.

The annual report of the American Telephone and Telegraph Co. for the year ending 31st December, 1928, which was issued in New York on March 1st, is now available. This report includes the operations of the American Bell Telephone Co., and it is possible therefore to make some interesting comparisons between the British and the American Telephone systems. The methods of keeping the accounts vary in detail, but, from the descriptions given in the American Report, it is possible to assemble the figures relating to the main heads of income and expenditure so that the financial results can be approximately compared. In dealing with finance, dollars are converted to sterling at the par rate of exchange. Of course, to get a real comparison it would be necessary to take into account the relative value of the currency, and its purchasing power in the two countries, as regards the standard of living in general, and the prices of the main items of telephone plant in particular. These complexities are outside the scope of this article.

Table 1 conveys a good idea of the extent and general lay out of the two systems. For the last years shown in the Table, the Bell Telephones consisted of approximately 78% manual and 22% automatic instruments, as compared with the British 87% manual and 13% automatic. (Bringing the British telephones up to the level date of 31st December, 1928, the total telephones had increased to 1,722,583, of which 85% were manual and 15% automatic). The number of Bell Telephones increased 5.8% in the year, as compared with the British 8.1%. The Bell average mileage per telephone was 4.28 and the British 4.40, including spare telephone wires in both cases. The Bell underground mileage was 66% of the total, and the British 84%. The Bell total mileage increased 9.5%, compared with 5.8% increase in the number of telephones, the corresponding British figures being 9.4% and 8.1% respectively.

A curious arithmetical discrepancy appears in the American report. The statistical table shows that 798,592 telephones were added during the year. In the body of the report it is stated that 4,235,000 telephones were connected and 3,485,000 disconnected, a net increase of only 750,000. The reason for such a considerable difference is not explained.

Finance.—Financial comparisons under the main heads of income and expenditure are given in Table 2 for the year 1928, and skeleton figures are shown for some of the corresponding American and British items in 1924 and 1925 respectively. In the Bell system, current maintenance covers " Cost of inspection, repairs and re-arrangements required to keep the plant and equipment in operating condition." In the Post Office accounts re-arrangements are charged against the depreciation fund, and for this reason the figures are not exactly comparable.

The average daily exchange calling rate in the Bell System was 3.98 as compared with the British 2.39; the toll rate was .21 for both systems.

The American report states that about one-fifth of all telephones receive service through private branch exchanges which are operated by employees of subscribers. Of the 14,524,648 telephones in December, 1928, therefore, approximately 2,904,930, (20%), were extensions on branch exchange switchboards, and the remaining 11,619,718, (80%), were simple telephones directly connected with the public exchanges. Of the 1,631,191 British telephones in March, 1928, approximately 523,338, (32%), were extensions on private exchange switchboards, and the remaining 1,107,853, (68%), were directly connected with the public exchanges. Only the calls passing through the public exchanges are counted in the statistics, and, based on these percentages, the Bell 4.19 local and toll calls represent about 5.25 per direct telephone per day, as compared with the British 3.8. The average calling rate for extension telephones is not known, but it is no doubt much higher than the rates for direct exchange lines. Taking this into account, together with the higher percentage of extension telephones in this country, the actual number of calls per telephone in the two countries probably does not differ so much as might appear from the published statistics.

The average income from the local exchange and toll services was £14.1 in the Bell system, as compared with the British £12.

The Bell maintenance cost was £2.2 per telephone, and the British £1.7, but when these costs are combined with the charges against the depreciation fund, the figures are—Bell £3.7 and British £2.7. As previously stated, the methods of allocation as between Maintenance and Depreciation are not quite the same with the two systems.

There is a wide difference between the Bell £46.3 prime cost value of plant and equipment per telephone, as compared with the British £77.3. In both cases the cost of land and buildings is included. It is not possible to explain this difference without full knowledge of the purchase price of materials and equipment, and this again is linked up with the complex question of relative taxation of industries in the two countries. (The cost of land and buildings is shown separately in the Bell figures for 1924 in Table 3).

In this country the great bulk of the exchange equipment has been provided and installed by contractors, and the same arrangement also applies to a considerable proportion of the underground plant. Assuming equal conditions in the matter of prices, the greater percentage of automatic telephones would tend to make the Bell system more expensive as regards the average cost per telephone. In America there is an extensive system of party line services which has some effect on keeping down the average cost per telephone, owing to the use of cheaper line plant and exchange equipment. Party lines are not popular with the public in this country. A large proportion of the British telephone plant was provided during the years of peak prices after the end of the War, and of course the cost of that inflation still remains as a standing charge. The growth of these capital charges over a period of years is well illustrated in Table 3. During the period from 1919 to 1924 the British total cost of telephone plant was doubled, and the cost per telephone increased from £49 to £66, a difference of £17 or 35%. During the same period the cost of the Bell plant was also nearly doubled, while the cost per telephone increased from £32 to £41, a difference of £9, or 28%. The Table shows marked increases in the cost per telephone with both systems in succeeding years since 1914. Increased density of development has therefore had the effect of increasing the cost per unit of plant, instead of reducing it as is so often suggested.

So far as the British figures are concerned, the increased costs are partly attributable to the great extension of the underground system which has taken place in recent years. The establishment of telephone repeater stations has been an expensive item, but this is off-set by a consequent cheapening of main cables, although the full effect of the latter has probably not yet been felt. During recent years also there has been a considerable increase in the number of telephone kiosks, which would have some effect on average costs. In March, 1928, there were 24,054 public call office stations, including 4,687 kiosks. The average capital costs are also increased by the extension of the automatic system owing to the more expensive exchange equipment which is required. No doubt these factors have also had their effect in increasing the average costs of the Bell system.

In the latest accounts the British depreciation reserve fund for telephone plant, land and buildings, amounted to £30,556,300 or £18.7 per telephone, and the American total was £133,680,159 or £9.2 per telephone. In addition to the depreciation reserves the Bell balance sheet shows £19,173,209 reserves for contingencies, and an accumulated surplus of £76,802,516.

Apart from prime cost values, it is remarkable how closely the figures agree in the American and British systems. If, however, we assume that sterling has twice the purchasing value for ordinary commodities in this country as compared with America, the analysis gives cause for some disquiet. Anything that can be done to reduce costs is bound to improve the prospects of developing the service, and an important factor affecting this question is the price of materials used and the manufacturers' charges for equipment. The economic organisation of the work, and the lay-out of the plant to the best possible advantage in the public interest are matters which are receiving very close attention both in this country and in America.

Table 4 shows the balances in the telephone net revenue accounts for the various years since 1912, after charging interest on capital, and after allowing for the depreciated value of the plant, and all other charges.

The heavy losses in the two years ending 31st March, 1921, were due to delay in raising the cost of service to correspond with the increased cost of materials and labour, pending the findings of the Select Committee appointed by Parliament to enquire into the organisation and administration of the Telephone Service and the method of making charges. This Committee reported in March, 1922, but the table shows that successful steps had been taken before that to stem the losses. More rapid progress was made after the charges were adjusted as a result of the Committee's recommendations.

Owing to the abnormally high prices prevailing, the revenue was debited with a special depreciation allowance of £200,000 annually from 1919 to 31st March, 1923, making a total of £800,000 for the four years; the deficit shown in the Table is increased by this amount.

The revenue accounts have been debited with a total sum of £2,181,954 in respect of Civil pay to telephone staff released for service with the Army and Navy during the War. It will be seen therefore that, apart from this sum, the losses and gains over the whole period to date nearly balance.

It is the policy of the Post Office to give back to subscribers the benefits resulting from profits, and large reductions of rates were made in July, 1922, July, 1923, and July, 1924. It is interesting to observe from a statement published by Sir Henry Bunbury, the Comptroller and Accountant General, that had these reductions not been made, and assuming that there would have been the same amount of business at the higher rates as in fact there was at the reduced rates, the surplus would have been :—

In 1922-23	£1,800,000	instead of	£1,244,000	difference	£556,000
,, 1923-24	£3,400,000	,, ,,	£1,718,000	,,	£1,682,000
,, 1924-25	£4,100,000	,, ,,	£852,000	,,	£3,248,000
Totals	£9,300,000	,, ,,	£3,814,000	,,	£5,486,000

These benefits have been continued since 1924-25.

After making provision for the payment of reasonable dividends to the stock-holders to ensure the necessary flow of capital, and after the payment of other expenses, the policy of the American Company is similar to that of the Post Office, viz. :—to furnish the best possible service at the least cost. The result of this policy is well expressed in the words of the 1928 report (dollars converted to sterling) as follows :—

" Effective February 1, 1929, there was a reduction in toll and long distance rates amounting to a saving to the users of about £1,026,000 annually. Also during 1928 the basic trans-oceanic telephone rate was cut from £15 to £9. Effective at the beginning of 1929 the American Telephone and Telegraph Company reduced its charge to its Associated Companies, under its contracts for services, from 2 per cent. to 1½ per cent. of the gross telephone revenues of those companies. This reduction amounts to about £940,000 annually, and is in accord with the practice of the American Telephone and Telegraph Company to do everything possible to aid its Associated Companies in keeping down the cost of telephone service. The Western Electric Company, Incorporated, reduced prices in 1928 by about £4,000,000 on the present annual volume of purchases by Bell System companies. This was accomplished largely by increased efficiency and improved methods of manufacture."

TABLE 1.

EXCHANGE AND TRUNK SYSTEM.

	AMERICAN BELL SYSTEM.								BRITISH TELEPHONE SYSTEM.					
	Dec., 1924	%	Dec., 1925	%	Dec., 1928	%	Increase during 1928	Incr. %	Mar., 1925	%	Mar., 1928	%	Increase during 1927-28	Incr. %
Telephones Manl. ...			10,538,935	87.6	11,377,632	78.3	201,746	1.8	1,223,243	96.0	1,4427,384	87.5	42,204	3.0
Telephones Auto. ...			1,496,289	12.4	3,147,016	21.7	596,846	23.4	50,557	4.0	203,807	12.5	80,201	64.7
Telephones Total ...	11,242,318		12,035,224	100	14,524,648	100	798,592	5.8	1,273,800	100	1,631,191	100	122,405	8.1
Exchange (British working).														
Miles of Wire														
Underground	24,760,252		28,425,392		37,843,154		2,681,198	7.6	3,101,556		4,719,708		546,026	13.1
Submarine	—		—		—		—	—	326		309		(39)	—
Aerial Cable ...	10,052,769		9,462,213		13,503,157		1,381,573	10.3	615,689		700,085		32,970	4.9
Open			1,953,235		2,069,381		73,542							
Total ...	34,813,021		39,840,840		53,415,692		4,136,313	8.4	3,717,571		5,420,102		578,957	12.0
Toll or Trunk (British working).														
Underground	1,893,660		2,057,196		3,237,550		512,505	18.8	326,725		507,932		38,256	8.1
Submarine	—		—		—		—	—	2,696		5,014		1,454	40.8
Aerial Cable ...	3,186,938		1,209,332		2,947,233		625,376	15.0	340,332		377,269		10,958	3.0
Open			2,366,172		2,592,269		95,655							
Total ...	5,080,598		5,632,700		8,777,052		1,233,536	16.4	669,753		890,215		50,668	6.0
Exchange and Toll (Working and Spare).														
Underground	26,653,912	66.81	30,482,588	67.0	41,080,704	66.1	3,193,703	8.4	3,891,808	79.6	6,048,318	84.4	572,328	10.4
Submarine	—	—	—		—	-	—	—	3,755	.08	6,604	.09	1,154	21.2
Aerial Cable ...	3,239,707	33.19	10 671.545	33.0	16,450,390	33.9	2,006,949	11.5	993,851	20.3	1,115,358	15.5	43,307	4.0
Open			4 319,407		4,661,650		169,197							
Total ...	39,893,619	100	45.473,540	100	62,192,744	100	5,369,849	9.5	4,880.414	100	7,170,280	100	616,789	9.4
Miles per Telephone (Working and Spare).														
Underground	2.37		2.53		2.83				3.05		3.71			
Submarine	—		—		—				.003		.004			
Aerial Cable ...	1.18		1.25		1.45				.78		.68			
Open														
Total ...	3.55		3.78		4.28				3.83		4.40			

NOTE.—In the British system, low gauge spare cable wires weighing 20lbs., or less, per mile, and open 40lbs. per mile are included in the "working" mileages.

TABLE 2.

TELEPHONE FINANCE AND STATISTICS OF THE AMERICAN BELL CO., AND THE BRITISH POST OFFICE.

	American Bell.		British Post Office.	
	31 Dec., 1924.	31 Dec., 1928.	31 Mar., 1925.	31 Mar., 1928.
Revenue :—		£		£
Local Exchange Service		132,362,656		18,695,371
Toll ,, ,,		63,557,499		
Advertising and Miscellaneous		4,496,287		135,844
Net value of Telegraph, Telephone Services		—		69,330
Total Revenue		200,416,442		18,900,545
Deduct bad debts		1,271,760		25,729
Total Income		199,144,682		18,874,816
Expenditure :—				
Current Maintenance	£20,874,651	31,735,214	£2,404,637	2,687,910
Traffic Expenses		43,568,130		
Commercial Expenses		18,245,839		5,011,878
General, Miscellaneous and Pension liability		10,454,127		925,676
		(72,268,096)		(5,937,554)
Rents, Rates, Taxes, etc.		19,329,432		1,008,484
				264,101
Depreciation charges	£20,483,483	31,616,131	£3,258,957	4,775,177
Total Expenses		154,948,873		14,673,226
Interest and Dividends		35,131,171		4,094,199
		190,080,044		18,767,425
Plant, Prime Cost	£465,774,289	673,040,240	£88,453,207	126,087,712
,, Depreciated Value		539,360,081		95,531,412
Reserves in Depreciation Fund		133,680,159	£21,910,111	30,556,300
Telephones at end of year	11,242,318	14,524,648	1,273,800	1,631,191
Increase in year	836,163	798,592	115,308	122,405
Mean number of telephones	10,824,236	14,925,352	1,216,146	1,569,989
Direct Exchange lines at end of year		—		1,041,543
Proportion of lines to Stations		—		10 : 16
Telephone Calls :—				
Exchange daily per telephone	4.07	3.98	2.46	2.39
Toll do.	.17	.21	.26	.21
Costs per telephone :—		£		£
Annual Income		14.1		12.0
,, expenses		11.0		9.3
,, maintenance	£1.9	2.2	£2.0	1.7
,, traffic, etc., expenses		5.1		3.8
Depreciation expenses	£1.9	2.2	£2.7	3.0
Plant, prime cost	£41.4	46.3	£69.4	77.3
,, depreciated value		37.1		58.6
Depreciation Fund		9.2	£17.2	18.7
Renewals and Plant displacement charged to Depreciation Fund :—		£		£
Amount		21,351,556		1,564,896
Cost per telephone		1.5		1.0
Maintenance as above		2.2		1.7
Renewals, etc., and Maintenance		3.7		2.7

TABLE 3.

PRIME COST OF TELEPHONE PLANT, LAND AND BUILDINGS.

Years ending—British Post Office, 31st March; American Bell, 31st December.

Year.	Telephones. British	British Plant, etc.	Amount.	Cost per Telephone. British.	American Bell.
			£	£	£
1913	730,763	Plant	27,513,814	37·65	
		Land and Buildings	3,100,000 (Estd.)	4·24	
		Total	30,613,814	41.89	
1914	774,821	Plant	30,137,043	38.89	
		Land and Buildings	3,538,673	4·57	
		Total	33,675,716	43·46	31·44
1915	796,348	Plant	33,208,845	41.70	
		Land and Buildings	3,544,786	4·45	
		Total	36,753,631	46.15	30·55
1919	797,218	Plant	35,057,431	43·97	
		Land and Buildings	3,658,802	4·59	
		Total	38,716,233	48.56	32·40
1923	1,050,672	Plant	62,648,362	59·62	
		Land and Buildings	4,409,631	4·20	
		Total	67,057,993	63·82	39·25
1924	1,158,492	Plant	71,801,538	61.98	37·40
		Land and Buildings	4,967,187	4·29	4·00
		Total	76,768,725	66.27	41·40
1925	1,273,800	Plant	83,050,253	65·20	
		Land and Buildings	5,402,954	4·24	
		Total	88,453,207	69·44	43·32
1927	1,508,786	Plant	106,882,126	70·84	
		Land and Buildings	7,050,616	4·67	
		Total	113,932,742	75·51	45·37
1928	1,631,191	Plant	117,935,820	72·30	
		Land and Buildings	8,151,892	5·00	
		Total	126,087,712	77·30	46·30

TABLE 4.

STATEMENT OF THE BALANCES SHOWN IN THE BRITISH TELEPHONE INCOME AND EXPENDITURE ACCOUNTS SINCE 31ST MARCH, 1912, AFTER CHARGING INTEREST ON CAPITAL.

Year ended 31st March.	Surplus.	Deficit.	Net Total to date. Surplus.	Deficit.
	£	£	£	£
1913	303,343	—	303,343	—
1914	239,111	—	542,454	—
1915	—	111,018	431,436	—
1916	—	118,177	313,259	—
1917	201,729	—	514,988	—
1918	355,468	—	870,456	—
1919	—	36,261	834,195	—
1920	—	1,961,710	—	1,127,515
1921	—	4,721,970	—	5,849,485
1922	—	559,132	—	6,408,617
1923	939,009	—	—	5,469,608
1924	1,596,917	—	—	3,872,691
1925	463,006	—	—	3,409,685
1926	550,830	—	—	2,858,855
1927	283,375	—	—	2,575,480
1928	107,391	—	—	2,468,089
Totals	5,040,179	7,508,268		2,468,089

SOME MODERN ASPECTS OF ELECTRICAL COMMUNICATION.

ADVANCES IN TELEPHONY AND TELEGRAPHY.

AT the Royal Society of Arts on Wednesday, April 10, a lecture was given by Mr. George Howard Nash, C.B.E., M.I.E.E., on " Some Modern Aspects of Electrical Communication." The Chair was taken by Sir Richard A. S. Paget, Bt. Mr. Nash observed that the Society had encouraged electrical communication from its earliest stages. The word " telephony " had appeared in the Journal of the Society as long ago as 1856, when it was applied to a method of transmitting musical sounds. Submarine telegraphy, the Hughes type-printing telegraph, and the D'Arlincourt method of transmitting writing, had all found a place in the Journal. The most important contribution to the subject that the Society had furnished, however, was the account on November 30, 1877, by Professor A. Graham Bell himself, of the articulating telephone, on which occasion the harmonic character of alternating electric currents was for the first time revealed and enthusiastically recognised. Since that time, in successive Cantor Lectures, the story of the development of Hertzian Wave telegraphy had been told in that room, and the advances in telephony had there been recorded. The present purpose was to make known to those who were not yet conversant with modern developments, some of the problems that arise on very long telephone connections, the means adopted for reducing or for overcoming difficulties, and to explain how, by modern methods of telephony and telegraphy, a number of communications can be made simultaneously, over a single pair of wires, without mutual interference.

The lecture was illustrated by a large diagram that indicated the main links — in a long telephone connection between two subscribers—over two continents, with an intermediate transoceanic link. An improved form of subscribers' set was shown, more convenient and more comfortable to use than the familiar pedestal type. The difficulty here to be surmounted was the variable distance between mouth and mouthpiece, owing to diversity of size of human heads. Entire freedom of movement of a speaker or listener during conversation by telephone was also a point to be gained by correct design of the set. Mr. Nash then proceeded to describe and to demonstrate a modern automatic system of telephony, and to distinguish this from a trunk exchange, *i.e.*, from an exchange designed for operating long-distance traffic. He explained that long lines are costly, and that consequently they cannot be increased indefinitely in number without raising the price of a call beyond what a subscriber is prepared to pay. The result is that the number must be reduced, with consequent occasional " delay," while subscribers await their turn. Service is thus provided on what is termed a " delay basis," the delay depending upon the number of calls waiting for a free line. This requires that calls shall be recorded at the trunk exchanges, and that the proper rotation shall be maintained by a system of tickets to operators. A recording switchboard with a belt conveyor for these tickets was shown. Where long distance telephony is more highly developed, a sufficient number of lines can be provided to supply a " no delay " service. The recording switchboard is then abandoned and a method of operation known as " the combined line and recording method " is introduced. In this method the trunk-line operator receives the call from the subscriber and makes out the ticket, but the subscriber does not hang up and wait to be called. Instead, the line operator completes the call to the required subscriber and connects the two with little or no delay. The ticket is then stamped. This saves recording positions and a good deal of ticket distributing equipment, and gives much faster service. From the various Trunk Exchanges, the circuit might, for example, now pass by means of " loaded " lines and " repeaters " to a Main Trunk Exchange, similar to an ordinary exchange, except that calls originating for a transoceanic radio link are received at a special position where they are dealt with by a technical control operator.

The arrangements at the Rugby Radio Station were then briefly explained by the lecturer, who referred to the fact that, as a supplement to the Long Wave Transatlantic Link, a Short Wave Circuit is now in operation, *i.e.*, two circuits are available during most hours. For purposes of demonstration it was assumed that, at the receiving station, links of communication with subscribers were installed similar to those on the transmitting side of the ocean.

Attention was then directed to certain effects that manifest themselves on long-distance telephone connections, which may involve aerial and cable circuits. On shorter connections these effects are present, but in less degree. They are:—(*a*) Attenuation distortion. (*b*) Phase distortion. (*c*) Echoes. (*d*) Interference.

(*a*) *Attenuation distortion,* sometimes called "frequency distortion," refers to the variation of the attenuation, or to the change of power efficiency, with frequency. An unloaded cable is a prolific source of such distortion, the attenuation increasing rapidly with frequency. The method of loading cables, commonly practised, by the insertion of lumped inductances, at intervals of about 6000 feet, causes the attenuation to remain relatively low over the most important part of the speech range, after which it rises to a value higher than in the absence of the loading. This results in a reduction of distortion over the essential part of the speech range, but in certain cases the residual distortion may still be intolerable. Attenuation distortion may be removed by the association of suitable resistance-reactance networks with the circuit; these are usually referred to as "attenuation equalisers" and introduce loss at the frequencies where the line loss is low, so that the sum of the line and equaliser loss approximates to a constant value for all frequencies transmitted. In certain cases, the reactance and capacities associated with the transformers of the amplifiers constituting part of a telephone repeater may be adapted to supply the necessary equalisation; this method has found favour in toll cable practice on account of its obvious economy. Long distance circuits are of course not exclusively confined to the transmission of speech and may be used for broadcasting or other purposes, such as picture transmission.

(*b*) *Phase distortion* is introduced by the difference in time of travel for different frequencies; it derives its name from the fact that the time of travel depends upon the way in which the phase shift of the complete system varies with frequency. The statement by Helmholtz that relative phase shift of different frequencies is not important, applies only to steady tones; it breaks down when the conditions are so extreme that parts of a finite wave-envelope starting at the same time arrive at the receiving end at different times, and when the difference in the time of arrival is greater than 30 milliseconds. In practice, for long distances, phase distortion is automatically eliminated by the fact that the repeaters normally used do not pass the frequency range above 2400 cycles. For two-wire circuits, high cut-off cables have the additional advantage that their speed of propagation is greater, which makes echoes less harmful. The fact that their impedance is more uniform within the pass-range, facilitates the construction of balancing networks; and as their attenuation distortion is small, very little correction is necessary. As an alternative to high cut-off circuits, the use of time delay correcting networks in an analagous manner to that of attenuation equalisers, has been proposed. These networks are either of the lattice or bridged T type, arranged so that they build up the time of travel of the fastest frequencies (*i.e.,* the low frequencies in this case) to be as nearly as possible equal to the time of travel of the slowest frequency in the pass-range of the system.

(*c*) *Echoes* are caused either by the return of part of the speech energy to the talker after an odd number of reflections, or by subsequent repetitions of the speech arriving at the receiving end after an even number of reflections. The term "reflection" is here intended to include any event during the process of which the original speech currents give rise to currents having the direction of propagation reversed. The type of long-distance circuit known as a "four-wire" circuit—in which a separate pair of wires is provided, respectively, for talking in each direction—was described. It was explained that, in practice, exact balance is never obtained. Consequently an indefinite number of separate echoes may arise, but these may be reduced so as to be of little importance. In the case of a "two-wire" circuit, each individual repeater has two balancing circuits associated with it, each of which affords the possibility of reflection taking place; but the reflection occurring at the terminals of the system is the most serious, because the balance there is always worse than at any other point in the circuit. This is on account of the fact that the end of the system has to be connected to a variety of circuits varying comparatively widely in impedance. To eliminate terminal echoes, it is usual to provide some means by which speech currents travelling through the circuit in one direction block the circuit operating in the other direction. This can only be done at a point in the circuit where four-wire operation occurs. In the case of a two-wire system the circuit is, in effect, converted to a four-wire circuit at every repeater in order to permit the insertion of one-way amplifiers. For this reason, and because the highest levels are obtained in the output of repeaters, echo suppressors, whether of the relay type or grid jamming type, are always associated with repeaters.

A typical arrangement for echo suppression used by the International Standard Electric Corporation on four-wire systems was then exhibited. It is in two halves, identical in function and differing only in the arrangement of their filament circuits to afford the most economical disposition. Within the working range, the behaviour of the apparatus is substantially independent of speech level in the line. In connection with the Transatlantic circuit, a special type of voice-operated switching device is employed which differs from a normal echo suppressor in that it is capable of suppressing an echo having zero delay. This is made necessary because of the desirability of operating transmitting and receiving stations on the same wave lengths, so that the receiving system is capable of amplifying the relatively weak signals received from the distant station and yet rejects the much stronger signals received from the local transmitting station. For this purpose, to avoid clipping of the speech, it is necessarry to introduce delay networks to retard the speech while switching operations are in progress.

The receiving circuit is normally through, and the transmitting circuit is normally blocked. Outgoing speech from the toll board arrives first of all at the amplifier detector bridged across the upper circuit it operates one relay which blocks the incoming circuit, and another relay which removes the short-circuit from the outgoing path. In this condition, incoming speech or noise has no effect on the circuit. With the cessation of outgoing speech, the circuit returns to normal. Incoming speech blocks the outgoing circuit and thus prevents any unbalance currents that pass the terminating set from operating the amplifier detector associated with the outgoing circuit. In every case the delay network is of such a length that the switching processes are complete before the speech arrives at the output of the delay network.

(*d*) *Interference* in telephone circuits may be inductive or may be introduced by the charging and floating machines associated with the power plants of the amplifier stations. In the case of radio links, the question of atmospherics has also to be considered. Inductive interference is introduced either by neighbouring power circuits, by telegraph circuits on the same route, or by speech circuits on the same route, in which case it is referred to as " crosstalk." Power induction is guarded against by careful survey of the route before laying the cable, by suitable transpositions in the power lines themselves, by bonding on electrified railways, and by selective interconnection of the conductors of the cable at joints, to balance the conductor capacities to earth. Interference from power plants is reduced to a minimum by separating power supply circuits from speech circuits and by the insertion of filters on the power supply leads. Reduction of telegraph interference is effected by the use of " noise killers " which are sometimes referred to as " shaping circuits." They consist of low-pass filters to suppress the high frequency components of the telegraph wave which are most serious in causing interference. Crosstalk is reduced to a minimum by careful adjustment of the speech levels, by balancing the internal capacities in each quad, and by special attention to the inductance and resistance balances of loading coils as well as by taking care to keep the conductor resistance of the cable itself balanced. Special care has to be taken in the lay-out of repeater stations and in the design of repeating coils, as well as in the arrangement of supply circuits both low tension and high tension, since these are always common to a large number of repeaters.

The question of atmospheric interference has been left to the last, since it is a very special problem in itself. During certain periods of the day and year, the interference by atmospherics coupled with fading in the signal strength, is sufficient to render the circuit entirely inoperative. To reduce this inoperative period to a minimum, special precautions are taken in the choice of wave lengths, in the location of the transmitting and receiving stations, in the type of antennæ, in the type of modulation process and in the operation of the circuit, to ensure that the maximum ratio of signal to noise is always obtained. Generally speaking it is always possible at any one time to choose such a wave length that satisfactory communication can be established, and this with a total use of only two or three wave lengths. The removal of the receiving station in England from Wroughton, Somersetshire, to Cupar, Scotland, was brought about purely on account of the better reception; and for the same reason the receiving station in America was located at Houlton, Maine.

Directional antennæ are used both for transmission and reception, and are an important factor in increasing signal strength and in reducing noise. The single side-band system of transmission in use at Rugby, in conjunction with complete carrier elimination, enables the highest degree of selectivity to be used in the receiving system, combined with maximum radiation of energy at the frequencies carrying the speech characteristics. In the operation of the circuit, precautions are taken to ensure that the radio transmitter is always fully loaded, irrespective of the strength of the speaker's voice, so that the maximum received field strength is always obtained.

Mr. Nash said that the evolution of radio links had now reached such a stage that the terminals of such a connection could be regarded in exactly the same way as the terminals of a land line connection—both from a technical and from an operating point of view. It was of course evident that, since radio links are usually costly, they should be operated on a similar basis to a high price long distance circuit, with maximum economy in line time. From a technical aspect, no two points on the earth are so remote from one another that it is impossible to connect them by long distance telephone. Obvious economic limitations of supply and demand up to now have prevented the installation of many very long circuits. The circuit which was recently set up between Stockholm and New York is an example of the possibilities of long distance communication. This circuit was 22,400 kms. long and was made up as follows:—

10,400	kms.	of Extra Light Loaded Cable.
4,700	,,	Radio Link.
6,850	,,	of Open Wire Line.
314	,,	of Submarine Cable.

It was equipped with 138 four-wire repeaters, 24 carrier repeaters, six cord-circuit repeaters and eight echo suppressors, including the special voice-operated switching device at London and New York.

He proceeded to consider how many simultaneous communications could be made over a single pair of wires. In any available telephone circuit of a type consisting either of aerial lines or short cable lines there is available for transmission purposes a frequency range extending from zero, or a few cycles per second, up to 30,000 cycles per second. Various communication systems have been designed to enable the maximum use to be made of this frequency range. These systems comprise:—(1) The Composite Telegraph System, which is superimposed on the telephone system and occupies the frequency range from 0—80 cycles. (2) The Carrier Telegraph System which occupies the frequency range from 3000 to 10,000 cycles. (3) The Carrier Telephone System which occupies the frequency range from 5000 to 30,000 cycles.

(1) *The Composite System*, on an open wire telephone circuit, provides two independent earth return telegraph channels. The speed of transmission over each channel may be up to 25 cycles per second, or approximately 60 words per minute, Morse, and by the use of the ordinary telegraph duplex balance, the transmission may be in two directions simultaneously.

As the use of telephone ringing current falls within the range 0 to 80 cycles, it is not permissible over a Composited circuit, since it would interfere with the telegraph; therefore it is necessary to insert special Composite Ringer apparatus on the Exchange side of the line repeating coils in all cases where the telephone signalling is by 16 cycle currents. The Composite Ringer translates the outgoing 16 cycle ringing current from the exchange to a higher frequency, frequently 135 or 500 cycles, and transmits this over the line. Similarly, it translates incoming calling signals from the line and transmits 16 cycle current to the exchange.

(2) *The Carrier Telegraph System* provides 10 independent telegraph channels in both directions, each channel being capable of transmission at a telegraph speed of 40 cycles per second. In carrier telegraphy, the currents are more severely attenuated than in the case of direct current telegraphy, and carrier telegraph repeaters must be provided to compensate for the increased attenuation. These repeaters have been designed so that their spacing will correspond with the telephone repeater spacing on the line, and it is thus possible to accommodate the telegraph repeaters in buildings already housing telephone repeaters.

(3) *Carrier Telephone Systems* provide one, three, or more channels over an open wire line or short underground or submarine cable which may be already in use for the usual purposes, *e.g.*, voice frequency telephony and composite telegraphy. From a trunk exchange operator's point of view there is no difference between a carrier circuit and any ordinary trunk circuit. The subscriber will notice only that the carrier circuit is free from the noise usually found on open wire trunk lines. The carrier equipment required can be classified roughly as carrier terminal equipment or carrier repeater equipment. At carrier terminals, the speech frequencies received from a subscriber's set are used to modulate the carrier frequency. Modulation has the effect of converting the speech frequencies to higher frequencies, and it is the latter which are transmitted along the line. At the receiving terminal, the high frequencies are " demodulated " or detected and thus brought back to their true place in the frequency scale. By moving the frequencies resulting from several subscribers' lines to different parts of the frequency scale, it is possible to provide several conversation channels on the same pair of wires. Separation between the frequencies resulting from the different conversations is effected by means of electric wave filters, each designed to pass a band of frequencies and to eliminate all others.

Carrier repeaters are used on lines where the attenuation is too great to permit of the use of terminals only. They have been designed so that their spacing corresponds with the usual spacing of voice frequency repeaters.

Although it might be thought that carrier apparatus must be comparatively expensive, it is found in practice to be otherwise. In many cases, particularly for distances greater than 200 miles, it is cheaper to instal and maintain carrier systems than to provide and maintain additional pairs of wires to give the same facilities. Indeed, a single channel system has proved to be the more economical for distances as short as 40 or 50 miles.

The following cases were then described :—

Case 1.
One normal telephone circuit.
Two composite telegraph circuits.
Three carrier telephone circuits.

A total of four telephone and two telegraph circuits.

Case 2.
One normal telephone circuit.
Two composite telegraph circuits.
Ten carrier telegraph circuits.

A total of one telephone and twelve telegraph circuits.

Case 3.
One normal telephone circuit.
Two composite telegraph circuits.
Three carrier telephone circuits.
Two carrier telegraph circuits.

A total of four telephone circuits and four telegraph circuits.

All the above telegraph circuits can be worked duplex.

In the first two cases these services can be operated at the same time without much difficulty, but in the third case careful consideration is necessary to ensure the location of the carrier telegraph channels in a range where they will not interfere with or be interfered with by the carrier telephone channels, and it is probable that they will be restricted to the range 3000 to 5000 cycles per second.

In the lecture room were set up two terminal equipments connected by a pair of wires and equipped with ordinary telephone sets, two composite telegraph channels, one carrier telephone channel and one carrier telegraph channel. By operating them all separately and then simultaneously, but only receiving one at a time, their simultaneous operation without interference was demonstrated.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

THE Annual General Meeting of the Institution was held at the Institution of Electrical Engineers, London, on Tuesday, May 14th, 1929. The Chair was taken by the President, Col. Sir Thomas F. Purves, M.I.E.E.

The Secretary read the report of the Council for the year 1928-29 and the reference to the honour of Knighthood recently conferred on Sir Thomas F. Purves by H.M. the King was received with enthusiasm. The Annual Statement of Accounts was presented by the Hon. Treasurer, Mr. C. J. Mercer. Mr. P. J. Ridd moved and Mr. A. O. Gibbon seconded that the Annual Report and Statement of Accounts be accepted and the meeting carried the resolution unanimously.

Mr. B. O. Anson moved that a vote of thanks be passed to the retiring members of Council and drew attention to the fact that this resolution was tinged with more than the usual regret as Mr. A. L. DeLattre was retiring from the Chairmanship of the Council after seven years of office. On behalf of the Council he thanked Mr. A. L. DeLattre for the skill, courtesy and leadership which had characterised his occupancy of the chair. Mr. W. A. Satchwell seconded the resolution which was carried with acclamation, and Mr. A. L. DeLattre replied.

The President then presented the medals for the Session 1927-28 as follows:—

Senior Silver Medals to Mr. A. H. Jacquest, A.M.I.E.E., and Mr. L. H. Harris, M.Sc. (Lon.), A.C.G.I., for their Paper on "Sparking and Arcing at Relay Contacts and the use of Spark Quench Circuits."

Senior Bronze Medal (in absentia) to Mr. C. Robinson, B.A., A.M.I.E.E., for his Paper on "The Submarine Link in International Telephony."

Junior Silver Medal to Mr. C. W. Brown, A.M.I.E.E., for his Paper on "The Director in Automatic Telephony. Its Application and the functions performed."

Junior Bronze Medal to Mr. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E., for his Paper on "Satellite Working in Automatic Telephone Areas."

The President then presented the Booth-Baudot Award of £5 and Certificate for the year 1928 to Mr. R. L. Ryan, Portishead Radio Station, for his suggestion "Method of Keying Tuning Fork Controlled Radio-telegraph Transmitters."

The meeting closed with the announcement by the President of the names of the Chairman and Vice-Chairman of the London Centre for the year 1929-30 as follows:—

Chairman—Mr. A. B. Hart, M.I.E.E.
Vice-Chairman—Mr. T. Cornfoot, M.I.E.E.

The Annual Meeting was followed by a meeting of the London Centre at which a very interesting lecture, illustrated by many slides, was given by Mr. F. Addey, B.Sc., F.R.A.S., entitled "The Royal Observatory, Greenwich."

LIST OF PRINTED PAPERS ISSUED DURING YEAR 1928-29.

No. 116. "The Director in Automatics. Its Application and the Functions performed," C. W. Brown, A.M.I.E.E.

No. 117. "The Submarine Link in International Telephony," C. Robinson, B.A., A.M.I.E.E.

No. 118. "Sparking and Arcing at Relay Contacts and the use of Spark Quench Circuits," A. H. Jacquest, A.M.I.E.E., and L. H. Harris, M.Sc. (Lond.), A.C.G.I.

No. 119. "The Problem of the P.B.X. connected to an Automatic Public Exchange," C. W. Brown, A.M.I.E.E., and R. J. Hines, B.Sc.

No. 120. "Satellite Working in Automatic Areas," F. I. Ray, B.Sc., F.H.D., A.M.I.E.E.

COUNCIL FOR THE YEAR 1929-30.

The constitution of the Council for the year 1929-30 is as follows:—

Chairman—Mr. E. H. Shaughnessy.
Honorary Treasurer—Mr. C. J. Mercer.
Representing Staff of the Engineer-in-Chief's Office—
Mr. B. O. Anson and Capt. J. G. Lucas.

Representing Executive Engineers—
London : Mr. J. Cowie.
Provinces : Capt. N. F. Cave-Browne-Cave.
,, Asst. & Second Class Engineers—
London : Mr. P. G. Hay.
Provinces : Mr. A. E. White.
,, Chief Inspectors—
London : Mr. J. N. Hill.
Provinces : Mr. W. A. Satchwell.
,, Clerical Staff—
London : Mr. E. H. M. Slattery.
Provinces : Mr. A. C. Smith and Mr. H. Willcock.
,, Inspectors—
London : Mr. N. Layton.
Provinces : Mr. Thos. Davidson.
,, Draughtsmen—
London and Provinces : Mr. R. J. Stewart.

Secretary—Dr. R. V. Hansford.

ESSAY COMPETITION, 1928-29.

The Judges have reported to the Council that the Prize Winners in the recent Essay Competition, arranged in order of merit, are as follows :

1. G. Franklin, E.-in-C.O.
   "Modern Theories of Electricity and Magnetism."
2. F. E. Wright, Repeater Station, Marks Tey.
   "Telephone Transmission Measurement on Repeater Circuits."
3. C. H. Hartwell, Brighton.
   "Maintenance of Subscribers' Apparatus in Automatic Areas."
4. N. V. Knight, E.-in-C.O.
   "Radio Methods in Telegraphy and Telephony."
5. W. H. Owens, Holborn Exchange.
   "General Analysis of Faults in a Director Automatic Exchange."

The Council has decided to award Certificates of Merit to the following four competitors who were next in order of merit :—

6. R. E. Gray, Reading.
   "Photo Copying and the Post Office Eng. Dept."
7. S. B. Iles, Manchester.
   "The Preparation of Development Schemes."
8. W. E. Everson, Repeater Station, Aldeburgh.
   "Landing the Shore End of a Submarine Cable."
9. H. Chapman, Testing Branch, Fordrough Lane, Birmingham.
   "The Study of the Oak."

There were 45 entries, and the Judges reported that although the number of essays submitted is smaller than in previous years the quality of the essays recommended for prizes and certificates is fully up to former standards.

R. V. Hansford,
Secretary.

May, 1929.

LOCAL CENTRE NOTES.

LONDON CENTRE.

The final meeting of the Session was held on May 14th, when Mr. Frederick Addey, B.Sc., F.R.A.S., gave a lecture on "The Royal Observatory, Greenwich." This lecture, specially arranged in connexion with a visit to the Observatory two days later, was most delightful and instructive. By means of an excellent series of lantern slides and lucid exposition Mr. Addey conducted his audience over the Observatory.

The hearty vote of thanks at the close of the meeting was a well-deserved tribute to the excellence of the lecture.

Informal Meetings.

The fifth Informal Meeting was held on March 26th, when Messrs. H. T. Bines and D. C. Maddocks gave an illustrated lecture entitled "Tandem and Holborn ; Construction and Maintenance" before a large audience. The many problems of "Tandem and Holborn" were very ably dealt with and a good discussion ensued.

The final Informal Meeting was held on 23rd April, when Mr. B. Lynn gave an illustrated lecture on "Straightforward Junction Working." Mr. Lynn showed that he was thoroughly conversant with the development of "Straightforward Junction Working" and the large audience and subsequent discussion proved the keen interest that was aroused. Mr. Lynn ably replied to the many points raised and a hearty vote of thanks closed another successful Session.

VISITS.

The Royal Observatory, Greenwich.

A visit was made on May 16th, the party being met and addressed in the Octagonal Room by the Astronomer Royal, Sir Frank Dyson. The party was then divided into groups and conducted over the Observatory.

The visit was interesting and instructive and this, together with the lecture two days earlier, made one more able to appreciate the value of the Observatory to us as a maritime nation.

T.H.

SCOTLAND EAST CENTRE.

SESSION 1928-29.

At the November meeting, Mr. E. J. Woods, A.M.I.E.E., read a paper on "The Main Underground System of Great Britain." The paper has already been referred to in the Journal. Mr. Woods, in a masterly reply dealing with various points raised in a keen discussion, furnished much useful information outlining Departmental policy.

At the January meeting, Mr. J. H. Douglas read a paper entitled "Notes on Battery Course —May, 1928." Included in the points dealt with were:—The necessity for a Technical Instruction on the subject; Diversity of opinion as regards theory and actual maintenance of lead accumulators; Future growth of secondary cell plant and training of staff; Necessity for complete discharge of cells; Oil on Electrolyte; Cadmium Test; Installation by direct labour; Standardisation of Secondary Cells; Distribution of current in cells; Cause of buckling of plates; Wood separators; Discharge frame; Counter E.M.F. batteries; Plantè and Faure plates; Details of faults, and visit to Messrs. Harte's Works. Mr. Douglas provided some valuable notes on Secondary Cell Maintenance for use by men in charge of small battery plants. The various points raised in the discussion were suitably answered.

Mr. H. Burgher's paper at the February meeting dealt with "Cabling and Cable Jointing." The paper was of a thoroughly practical nature and contained many useful suggestions and much constructive criticism. The improved results obtained from the fuller use of motor transport facilities during cabling operations were described, and the necessity for adhering to instructions relating to cable jointing was emphasised. In the evening, members visited "The Scotsman" Office. Much interest was taken in the power plant recently installed for petrol, paraffin or gas as an alternative to the City Electricity Supply, and in the tele-photo apparatus of M. Bélin, and also the Murray Multiplex column printing telegraphs, as well as in the general work of the production of an important daily newspaper. The skilful guidance of Mr. W. P. Morris, of "The Scotsman," was greatly appreciated.

An informal meeting was held in March, when short papers introducing the following subjects were read:—

"Electrolytic Testing," by Mr. J. T. Gillespie, A.M.I.E.E.
"Changing Ideas on Costing," by Mr. J. Lomax.
"Works Order Excesses," by Mr. E. J. Fraser.

Mr. Gillespie described the various tests, the apparatus used, the different conditions met with, and the points to be observed when preparing a record of the observations and the results obtained.

Mr. Lomax reviewed the faults and weaknesses of the old system and indicated the advantages of the costing system now in force.

Mr. Fraser directed attention to the detection and treatment of excesses and the necessity for the timeous formulating of applications for authority to enable the altered conditions to be considered and approved before any additional cost is incurred.

The concluding meeting of the Session was held in April, when Mr. R. Goodfellow contributed a paper on the "Training of Youths." The problem had been engaging the attention of educationists and employers of labour for a number of years and it was one always bristling with difficulties and generally difficult of solution. The real necessity for "Earnestness" on the part of youths was essential to success, and the cultivation of useful habits and the desirability of avoiding distraction were emphasised, The policy pursued by the Department was explained and it was felt that the modifications recently introduced would provide an organised scheme of education enabling any student starting at the lowest educational grade to proceed as far as his ability would take him. The new scheme was undoubtedly a step in the right direction.

The meetings were all well attended and hearty votes of thanks were accorded the lecturers.

SOUTH LANCS. CENTRE.

The 1928-29 Session was opened on the 15th October, 1928, with an address by the Chairman, Mr. W. J. Medlyn, in which, under the title of " Progress and Development in the Engineering Department," an interesting account was given of the activities of the Post Office, and the latest development in engineering practice. The address, which was greatly appreciated, was followed by a cinematograph film entitled " Voices across the Sea," giving an interesting description of the Anglo-American Telephone services.

At the second meeting, held on 12th November, 1928, a paper entitled " Automatic Telephony—Trunking and Grading " was read by Mr. H. P. Clyma. The paper opened with a very clear and concise explanation of the economic necessity of grading, and, with the aid of an excellent series of lantern slides, the lecturer gave an instructive description of the way in which trunking and grading are carried out in an Automatic Exchange.

The third meeting of the Session was held on 17th December, 1928, and Mr. H. M. Turner read a paper on " Secondary Cells." In view of the rapid increase in the amount of secondary battery plant, consequent upon the introduction of automatic switching and repeater working, the paper proved to be of exceptional interest and value. The author's presentation of the main points of his paper, illustrated by numerous lantern slides, was greatly appreciated. A valuable discussion followed in which representatives of several battery manufacturers also took part.

At the fourth meeting, held on 14th January, 1929, Mr. E. J. Woods, of the Engineer-in-Chief's Office, read a paper entitled " The Main Underground Trunk Cable System of the British Isles." This paper, which gave a very comprehensive summary of the growth of the main underground system and concluded with a survey of the recent changes of practice and policy in main cable design, evoked an interesting and useful discussion.

At the fifth meeting, held on 11th February, 1929, a paper was read by Mr. R. G. De Wardt on the " Wireless Beam System." The paper, which was illustrated by a number of lantern slides of the Grimsby Beam Radio Station, gave a clear outline of the principles of beam working, and the various practical problems which had to be dealt with in their application. A good discussion resulted.

The sixth meeting was held on 11th March, 1929, when Mr. E. S. Ritter, of the Engineer-in-Chief's Research Section, read a paper on " Picture Telegraphy." This gave a very clear description of the development of the various systems of electrical transmission of pictures, and the application of the photo-cell to such systems was demonstrated in an interesting manner. From the excellent series of lantern slides shown, and photographic prints displayed, members were able to see the wonderful strides made in this branch of Telegraphy during the last few years.

At the final meeting of the Session, which was held on 8th April, 1929, Mr. A. J. Aldridge, of the Engineer-in-Chief's Research Section, read a paper entitled " The Measurement of Sound and its application to Telephony." On account of its length, the paper had to be presented in a somewhat abbreviated form, but the main features were given by the author in a very interesting and instructive manner. Many important points were raised in the discussion which followed, and to these points the lecturer adequately replied.

SCOTLAND WEST CENTRE.

The fourth meeting of the Session was held in the Societies' Room, Royal Technical College, Glasgow, on 4th March, when a paper entitled " Notes on Battery Course, May, 1928," was read by Mr. J. H. Douglas, of the Edinburgh Central Automatic Exchange. The subject was dealt with in a clear and exhaustive manner and the questions raised indicated that it was of considerable interest to the members.

H.C.M.

NORTH WESTERN CENTRE.

The discussion of Mr. C. Coward's paper on "Unit Construction and Maintenance Costs (External) from Fundamentals," which was read on the 25th February, was resumed in St. George's Hall, Preston, on the 18th March, 1929.

The Chairman of the Centre (Mr. J. M. Shackleton, M.I.E.E.) presided.

The proceedings were opened by the Vice-Chairman (Mr. S. Upton, M.I.E.E.), who reviewed the salient points of the paper and suggested lines on which the discussion might usefully proceed. There was no lack of speakers, and although the meeting lasted for over three hours there were clear indications that the subject had by no means been exhausted when the meeting terminated. Mr. Coward suitably dealt with the points raised in the discussion.

The closing meeting of the 1928-29 Session was held on the 22nd April, 1929, when a paper entitled "Petrol Engines with special reference to the Electrical Circuits" was read by Mr. H. Horrocks.

Mr. J. M. Shackleton presided.

The paper was divided, broadly, into two parts; the first part dealing with the mechanical, and the second part with the electrical aspect of the subject.

Mr. Horrocks opened with a review of the evolution of the petrol engine, especially as applied to road vehicles. He then described the internal combustion engine on the four-cycle principle and passed on to a detailed description of the modern engine. The methods of ignition, etc., were given prominence and the general electrical details described at length.

Local Organization, 1929-30.

Chairman—Mr. J. M. Shackleton, M.I.E.E.
Vice-Chairman—Mr. S. Upton, M.I.E.E.
Committee—Messrs. A. S. Carr, R. A. G. Chambers, W. H. Lane, W. G. Morris, H. F. Perry and A. W. Whittaker.
Librarian—Mr. H. Howarth.
Secretary—Mr. D. Barratt, Superintending Engineers' Office, Cross Street, Preston.

D.B.

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A. T. Kingston, Esq., M.B.E., A.M.I.E.E.,
Office of the Chief Engineer,
Telegraphs & Telephones,
C.T.O.,
Colombo,
Ceylon.

A. J. Kellaway, Esq.,
Department of Posts and Telegraphs,
P.O. Box 366,
Pietermaritzburg,
South Africa.

CURRENT LITERATURE.

The Journal of the Instiution of Electrical Engineers. Vol. 67. No. 387. March, 1929.

Electrical Equipment of the Singapore Floating Dock. Ernest T. Williams, O.B.E., Member.

Note on Sheath Losses in Single-Core Single-Phase Cables. Professor W. Cramp, D.Sc., Member, and G. M. Harvey, Associate Member. Eddy current losses in pair of sheaths undergo a change as sheaths are removed from position of intimate contact.

A Critical Study of a Three-phase System of Unarmoured Single-Conductor Cables, from the Standpoint of the Power Losses, Line Constants and Interference with Communication Circuits. E. B. Wedmore, Member, P. D. Morgan, B.Sc. (Eng.), Associate Member, and S. Whitehead, M.A., Associate Member. Technical Report from the British Electrical and Allied Industries Research Association, with seven Appendices in which the problems are tackled mathmatically. In their conclusions, the authors state that on account of the complexity of specific problems, such as the separation to render negligible any interference between power and communication circuits, they are best solved experimentally, so that co-operative research between telephone and power engineers will no doubt be needed shortly. [*Certain tests in this direction have been carried out on the Bedford-Little Barford length of the power grid now erected.—Eds., P.O.E.E. Jnl.*]

Vol. 67. No. 388. April, 1929.

The Electrical Equipment of X-Ray Apparatus. L. G. H. Sarsfield, M.Sc., Associate Member.

The Continuously-Loaded Submarine Telegraph Cable. A. E. Foster, P. G. Ledger, Member, and A. Rosen, B.Sc. (Eng.), Ph.D., Associate Member. The earlier non-loaded type is referred to briefly and the more recent loaded type is treated in somewhat greater detail, special reference being made to the Fanning Island-Suva (Fiji) section of the Pacific Cable (1926). In the non-loaded cable, distortion and attenuation of signals may be reduced and the speed of signalling increased by increasing the section of the conductor, but there is a limit to this procedure. The discovery of high permeability alloys with low magnetising forces has made possible the loading of telegraph cables with consequent increase of signalling speed. A description is given of the method of treatment during manufacture and the method of applying the loading material to the conductor is described. The theory of transmission of impulses through loaded cables is briefly discussed and some details of the methods of testing during manufacture and after laying are given.

The Design of Transmitting Aerials for Broadcasting Stations. P. P. Eckersley, Member, T. L. Eckersley, B.A., B.Sc., and H. L. Kirke.

Thermal Transference in Transformer Coils. Report (Ref. E/T 27) of the British Electrical and Allied Industries Research Association.

Discussion on " A Generalised Analysis of the Triode Valve Equivalent Network." Paper by Mr. F. M. Colebrook, given in earlier issue, page 157 of Volume.

Precautions in the Use of Electrical Instruments. W. H. Lawes, B.Sc., Associate Member. Paper summarises precautions to be adopted in purchase, installation and use of electrical instruments, the errors to be expected and their control.

The Institution Annual Dinner, 1929. Report of.

The Part played by Mr. St. George Lane Fox Pitt in the Invention of the Carbon Incandescent Electric Lamp and the Modern Method of Electric Lighting. A. A. Campbell Swinton, F.R.S., Member.

Vol. 67. No. 389. May, 1929.

An Introduction to Researches on Circuit Breaking. E. B. Wedmore, Member, W. B. Whitney, Ph.D. (Eng.), Member, and C. E. R. Bruce, M.A., B.Sc. Report (Ref. G/T 34) of the British Electrical and Allied Industries Research Association.

The Anticipation of Demand and the Economic Selection, Provision and Lay-out of Plant (Telephone Systems). Captain J. G. Hines, Member. A description of the methods employed by the British Post Office in making telephone development studies, framing lay-out schemes and determining the economic period for which to provide plant. The paper was read in conjunction with another paper with the same title but applying to Power Systems, and the points of similarity and dissimilarity are discussed.

The Mathematical Theory of the Magnetic Field round a Circular Current and Allied Problems. Alexander Russell, M.A., D.Sc., L.L.D., F.R.S., Past-President.

Electric Lifts. L. Burdes, B.Sc. (Eng.), Student.

Control Equipment for Direct-Current Trains. J. W. Gibson, B.Eng.

Carrier Telephone Systems. J. A. H. Lloyd, M.Eng., Student. The paper outlines the trend of development in carrier telephone systems in the past, the practical application of these systems, and the working of carrier terminal, repeater and associated equipments, and then summarises the uses and advantages of these systems.

Phase Advancing, with particular reference to the Scherbius Shunt-Wound Advancer. C. J. O. Garrard, M.Sc., Student.

Journal of the American Institution of Electrical Engineers. March, 1929.

Study of Noises in Electrical Apparatus. T. Spooner and J. P Foltz. Descriptions of resonance types of sound analysers for the study of noises in gears, motors, etc.

A New High-Accuracy Current Transformer. M. S. Wilson.

Anomalous Conduction as a Cause of Dielectric Absorption. J. B. Whitehead and R. H. Mardin.

Telemetering. C. H. Linder, C. E. Stewart, H. B. Rex and A. S. Fitzgerald. The problem of transmitting instrument readings or their equivalents from one point to another.

Revolving Field Theory of the Capacitator Motor. Wayne J. Morrill.

Electrical Aids to Navigation. Robert H. Marriott. Electrical and magnetic aids to navigation by water and air are outlined.

Two - Reaction Theory of Synchronous Machines. R. H. Park.

Corona Ellipses. V. Karapetoff. A mathematical theory of the cyclograms of Corona obtained by a cathode ray oscillograph.

Losses in Armoured Single Conductor Lead-Covered A.C. Cables. O. R. Schurig, H. P. Kulhni, F. H. Buller.

Power Transmission and Distribution. Concluding report of the 1927-8 Sub-Committee, giving the latest data of the sub-committee on protection of transmission lines against lightning.

Carrier Current and Supervisory Control on Alabama Power Coy's system. W. I. Woodcock and E. W. Robinson. The experience of the company with carrier current telephony over power lines.

Flux Linkages and Electro-magnetic Induction in Closed Circuits. L. V. Bewley.

Decibel. The Name for the Transmission Unit. W. H. Martin. Summary tracing the evolution of the " Neper " and the " Bel."

Separation of Stray Load Losses in A.C. Generators. M. C. Holmes.

Insulation Tests of Electrical Machinery, before and after being placed in service. C. M. Gilt and B. L. Barnes. Ratios of test to working voltages are recommended for tests made on site after installation and periodically throughout the life of the plant.

Line-Start Induction Motors. C. J. Koch.

April, 1929.

Oscillographs for recording Transient Phenomena. W. A. Marrison. Two instruments and their performances are described and illustrated for recording very short or very long transients; they may be used in combination.

Vector Presentation of Broad-Band Wave Filters. R. F. Mallina and O. Knackmuss. Function of a broad-band wave filter of the iterative ladder type explained in terms of two characteristic vectors. Diagram shows the relationship between a mid-series and a mid-shunt structure.

Short-Circuit Testing on Alabama Power Coy.'s System. H. J. Scholz and C. B. Hawkins.

Transient Analysis of A.C. Machinery. Yu H. Ku.

The Condenser Motor. Benjamin F. Bailey.

Theoretical and Field Investigations of Lightning. C. L. Fortescue, A. L. Atherton and J.

H. Cox. A review of some recent methods of studying lightning phenomena. Theory of travelling waves along transmission lines with reflections at open and earthed ends is discussed. How surges are produced by lightning and the effect of earth resistance.

Power Factor and Dielectric Constant in Viscous Dielectrics. Donald W. Kitchin.

No-Load Induction Motor Core Losses. T. Spooner and C. W. Kincaid.

The Predominating Influence of Moisture and Electrolytic Material upon Textiles as Insulators. R. R. Williams and E. J. Murphy.

South Eastern Power and Light System. A. T. Hutchins.

Automatic Re-closing High-Speed Circuit Breaker. A. E. Anderson.

Automatic Mercury Rectifier Sub-stations in Chicago. A. M. Garrett.

Lightning. Progress in Lightning Research in the Field and in the Laboratory. F. W. Peek, Jnr.

Bushing - Type Current Transformers for Metering. A. Boyajian and W. F. Skeets.

The Post College Education of Engineers Edward Bennett, Chairman of the Committee on Education. Recommendations.

132-KV Shielded Potentiometer, for determining the accuracy of Potential Transformers. C. T. Weller.

Illumination Items. Centre fixture in residence lighting. Traffic Control. Industrial lighting practice. Helen G. McKinlay, W. T. Dempsey and A. D. Bell.

May, 1929.

Operating Experience with the Low Voltage A.C. Network in Cincinnati. F. E. Pinckard.

Electrical Equipment of Bar Plate and Hot Strip Mills. J. B. Ink.

Effect of Transient Voltages on Power Transformer Design. K. K. Palueff.

Street Railway Power Economics. J. A. Noertker.

Recent Development in Telephone Construction Practice. B. S. Wagner and A. C. Burroway. An abridgement of the paper in which are described recent developments in telephone construction practice which react to preserve the integrity of the sheath of lead-covered cable, thus decreasing insulation troubles due to moisture seeping through armour breaks and warding-off service interruptions.

Iron Losses in Turbine Generators. C. M. Laffoon and J. F. Calvert.

Cathode Ray Oscillograph Study of Artificial Lightning Surges on the Turners Falls Transmission Line. K. B. McEachron and V. E. Goodwin.

Lighting of Airways and Airports. H. E. Mahan.

The Fabrication of Large Rotating Machinery. H. V. Putman.

Electrical Features of the Kansas City New Water Works. Albert L. Maillard.

Fused Arcing Horns and Grading Rings: Design, Construction and Operating experience on 66,000 volt Transmission Lines of the Union Gas and Electric Co. Philip Stewart.

Arc Welding of Steel Buildings and Bridges. Frank P. McKibben.

Illumination Items. The present status of Light Sources and Window Material. A device for measuring Average Voltage.

BOOK REVIEWS.

" Alkaline Accumulators." By J. T. Crennel, B.A., and F. M. Lea, M.Sc. 132 pp. 10/6 nett. Longmans Green & Co.

The alkaline or so called nickle iron accumulator has developed rapidly of late years and is now proving a serious rival of the lead acid cell in some branches of industry. Very little technical information has hitherto been available regarding this type of cell and the publication of this book which the authors claim represents a summary of all the available information on the subject is therefore very welcome. The development, construction, manufacture, theory, characteristics, operation and maintenance are dealt with, much of it in a manner which makes it understandable to the purely practical man. A very fair comparison is also made of the relative merits and deficiencies of the lead acid and alkaline cell.

Although the book contains a large amount of very useful information one is left with the impression that there is still much to be learned before our knowledge of the alkaline cell is as extensive as that of the lead acid accumulator.

H.C.J.

" The A.B.C. of Storage Battery Management." By Ernest C. McKinnon, M.I.E.E. 121 pp. 3/6 nett. Chloride Electrical Storage Coy., Ltd.

Although some 70 years have elapsed since Plante commenced the classic experiments which were the nucleus of modern storage battery design, it is surprising to find that to many people with extensive knowledge of other branches of electrical engineering the behaviour of the secondary cell is shrouded in complete mystery. This is no doubt due to the paucity there has been of suitable literature on the subject, but Mr. McKinnon's publication should go a long way to remove any deficiency there may have been in this direction. The book treats the whole subject of secondary cell maintenance in a very understandable yet comprehensive manner and can be confidently recommended to all those in any way interested in secondary cells. It is of course confined to cells of the lead acid type.

H.C.J.

" Operational Circuit Analysis." Vannevar Bush, Eng.D. New York: John Wiley & Sons, Inc., 1929. London: Chapman & Hall, Limited. 22/6 nett.

The author of this book is to be congratulated on producing a work which contains, not only a general discussion, *ab initio,* of the Heaviside Operational Calculus, but also brings together in one text the modern developments of the subject, which can be found only in scattered papers and there accompanied by formidable mathematical difficulties.

It is now over forty years since Oliver Heaviside first began to publish his classical *Electrical Papers* and with them his operational methods of solving the differential equations of electric circuit theory. His methods met with a certain success—the kind that the French term a *succès de scandale.* Many engineers regarded his conclusions as absurd, whilst mathematicians were bewildered by the eruption in his proofs of mysterious operators such as $\sqrt{\frac{d}{dt}}$. The result was that Heaviside's great work was nearly forgotten and unused for many years. But, as the author points out in his first chapter, the modern developments of electrical engineering have resulted in circuit and field problems becoming inherently more difficult to analyse and requiring for their solution mathematical methods similar to those invented by Heaviside.

The first part of the book deals with the mathematical theory of the direct operational method, where the Heaviside operational equation is interpreted as a solution of an infinite integral equation of the Laplace type. Heaviside was the first to recognise this equivalence; he did not, however, make much use of it in his researches. The author developes the subject rigorously and produces a delightful looking theory. Trouble arises, however, as soon as this theory is applied to practical circuit or field problems. The infinite integral equations which arise can only be evaluated by advanced mathematical methods—methods which are, through human fallibility, as likely as not, to give the wrong answer. Of course, one may follow the author's advice of referring to a table of infinite integrals and then transforming into the desired form. But for the reader to use a formula without understanding it, or without ever having understood it, and then to transform this formula, savours very much of an unintelligent faith in Mumbo Jumbo. Heaviside made no pretence to rigorous formalism, but allowed only physical, geometrical and analytical ideas to guide him. This is the essential difference between his methods and those of the " Infinite Integralists." This is a point that the author has apparently overlooked.

The author then deals with the application of the Fourier integral to electric circuit theory. The general method of solution is by contour integration in the complex plane and the calculus of residues. By this process it has been successfully applied to the solution of special problems. The author then discusses very briefly the theory of functions of a complex variable and shows the connection between the Fourier analysis and the operational method.

The reader will, no doubt, think it strange that the author when dealing with real variables finds it necessary to use the complex variable. Complex integration was introduced into operational theory by Bromwich and the idea has gained ground that the operational method is only an easy way of writing contour integrals. This, however, is not the case; the complex integral forms a convenient method of evaluating the Heaviside operators that apparently satisfies the æsthetic taste of the mathematical rigorist.

The book can be thoroughly recommended to readers. Te author has handled his subject in an able manner with the result that the book is very readable and in places even entertaining.

" Electrical Transmission and Distribution." Edited by R. O. Kapp, B.Sc. Sir Isaac Pitman & Son. Volumes V. and VI. 6/- each.

These volumes form part of a series of eight, of which Volumes I. and II. were reviewed in the last issue of this Journal, on the extensive subject of Electrical Transmission and Distribution.

The two volumes under review cover substation work, the first dealing with the construction and maintenance of the machinery used in modern practice, the second with the various types of sub-stations with a section on testing, maintenance and operation. Both volumes are divided into sections each written by an expert on the particular subject dealt with.

Volume V. comprises four sections on the following subjects: " The Construction of Transformers," " Converting machinery," " Mercury Vapour Rectifiers " and " The Handling, Care and Protection of Transformers" respectively. The theoretical side of the subject is not stressed in any section, the book being chiefly concerned with what are usually termed " practical " matters. The diagrams and illustrations, especially the latter, are very clear and are more profuse than is usual in technical books.

Volume VI. is divided into three sections, the largest dealing with " The Testing maintenance and operation of Sub-stations." This subject is dealt with more fully than the others and, forming the main part of the book, gives a lucid description of the latest methods employed.

The " Design and Lay-out of Sub-stations " is the title of a brief section, whilst the third section deals more fully with automatic substations and their operation.

The clear diagrams and illustrations are a noteworthy feature of this volume also.

Both volumes are indexed.

J.B.

Kempe's Engineer's Year-Book for 1929. Crosby Lockwood & Son, London. 30/- net.

This year's issue, which forms the thirty-sixth edition, contains 3,264 pages, with over 3,000 illustrations, has a cubic content of 7″ × 5″ × 4″ and weighs about 5 lbs. avoirdupois. The mass is very considerable, but it is doubtful whether any part could be omitted if the opinion of the engineering world on the subject could be obtained and summarised. The book needs no introduction nor commendation to Post Office engineers, who have grown up in the knowledge and esteem of the author and who know the amount of skilled and classified labour that has been given to the compilation of the work.

There are some fifty sections which cover all branches of engineering practice, including one containing legal notes for engineers and an appendix of trade terms in English, French, Italian, Spanish and Russian. A very complete index is furnished, by means of which data on any subject can readily be found. A copy of the book should be on the shelves of every engineer whose interests are wider than his own immediate job; even the specialist will find some information on his own subject which he cannot carry in his head.

" The A.T.M. Telegraph Engineers' Handbook." The Automatic Telephone Manufacturing Coy., Ltd. Price 2/6.

This handbook is packed full of formulæ and figures and it will be found very useful to telegraph engineers as a book of reference.

The book is divided into nine sections, the first two of which deal with telegraph transmission theory. The third section deals with transient phenomena and is arranged in an attractive manner, the formulæ being deduced and not merely quoted. The fourth section deals with the theory and application of the A.T.M. Gulstad Relay. This is followed by a section dealing with Relay Testing sets. Sections 6 and 7 are technical descriptions of the A.T.M. Universal Duplex Unit and the Vyle Polarised Sounder respectively. Section 8 consists of a table of Exponential and Hyperbolic Functions. The last section is a list of the A.T.M. Telegraph products. The theoretical matter in the book has been ably dealt with, and the formulæ and illustrations are clearly reproduced.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	Grade.	Promoted to	Date.
Hansford, R. V., D.Sc.	Acting Assistant Staff Engineer, Radio Section, E.-in-C.O.	Assistant Staff Engineer, Radio Section, E.-in-C.O.	17-4-29
Blight, W. O.	Executive Engineer, Equipment Section, E.-in-C.O.	Acting Assistant Staff Engineer, Equipment Section, E.-in-C.O.	1-4-29
Aspinall, H. O.	Assistant Engineer, N.W. (Extl.) Section, London District.	Executive Engineer, Centre (Extl.) Section, London District.	1-8-29
Smith, J. I.	Assistant Engineer, Middlesboro' Section, N. District.	Executive Engineer, Middlesboro' Section, N. District.	2-7-29
Ireland, W.	Assistant Engineer, Equipment Section, E.-in-C.O.	Executive Engineer, Inverness Section, Scotland East District.	5-9-29
Gray, H. C.	Assistant Engineer, Centre (Intl.) Section, London District.	Executive Engineer, Technical Section, S. Mid. District.	1-9-29
Hill, S. F.	Assistant Engineer, Equipment Section, E.-in-C.O.	Executive Engineer, Birmingham (Intl.) Section, N. Wales District.	1-7-29
Watkins, J. H., M.C.	Assistant Engineer, Technical Section, London District.	Executive Engineer, Bangor Section, N. Wales District.	1-7-29
Frost, P. B.	Assistant Engineer, Equipment Section, E.-in-C.O.	Executive Engineer, Equipment Section, E.-in-C.O.	24-4-29
Jacquest, A. H.	Assistant Engineer, Telephone Section, E.-in-C.O.	Executive Engineer, N. Ireland District.	26-5-29
Jones, L. J.	Assistant Engineer, Radio Section, E.-in-C.O.	Executive Engineer, N.E. (Intl.) Section, London District.	1-8-29
McKichan, J. J., O.B.E.	Assistant Engineer, Telephone Section, E.-in-C.O.	Executive Engineer, Lines Section, E.-in-C.O.	24-4-29
Banks, A. E.	Assistant Engineer, Manchester (Intl.) Section, S. Lancs. District.	Executive Engineer, Leicester Section, N. Mid. District.	1-7-29
Legg, Capt. J.	Assistant Engineer, Test Section, E.-in-C.O.	Acting Executive Engineer, Testing Branch, London.	24-4-29
Keyworth, F.	Skilled Workman, Class I., Telegraph Section, E.-in-C.O.	Inspector, Telegraph Section, E.-in-C.O.	To be fixed later.
Sturges, A.	Skilled Workman, Class I., Testing Branch.	Inspector, Testing Branch.	
Bull, R. S.	Unestablished Skilled Workman, Testing Branch.	Inspector, Testing Branch.	

Appointments.

Name.	From	To	Date.
Ackerman, H. M. W.	Probationary Assistant Engineer, S. Lancs. District.	Asst. Engineer, S. Lancs. District.	1-4-29
Potts, E.	Probationary Assistant Engineer, E.-in-C.O.	Assistant Engineer, E.-in-C.O.	
Hibberd, W. A.	Probationary Assistant Engineer, E.-in-C.O.	Assistant Engineer, E.-in-C.O.	
Luxton, W. G.	Probationary Assistant Engineer, E.-in-C.O.	Assistant Engineer, E.-in-C.O.	
Dallow, J. C.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	1-4-29
Birch, S.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	
Joyce, R. M.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	
Stevens, E. C. C.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	
Wootten, L. G.	Probationary Insp., London District.	Inspector, London District.	
Partridge, F. V.	Probationary Insp., London District.	Inspector, London District.	
Lee, A.	Probationary Insp., London District.	Inspector, London District.	
Challinor, W.	Probationary Insp., London District.	Inspector, London District.	
Collett, W. A.	Probationary Inspector, E.-in-C.O.	Inspector, E.-in-C.O.	
Evans, T.	Probationary Insp., S. Lancs. Dist.	Inspector, S. Lancs. District.	
Sharpe, H. T. A.	Probationary Insp., London District.	Inspector, London District.	
McDougald, F. M.	Probationary Insp., N. Mid. Dist.	Inspector, N. Mid. District.	
Pengelly, R. H.	Inspector, Radio.	Postmaster, Helston.	4-4-29
Chandler, R. W.	Inspector, Grimsby Radio.	Assistant Traffic Superintendent.	14-4-29
Simpson, C.	Inspector, N. Ireland District.	Assistant Superintendent of Traffic.	28-4-29

Transfers

Name.	Rank.	From	To	Date.
Harding, R. W.	Executive Engineer	S. Mid. District.	E.-in-C.O.	1-9-29
Deane, W.	,,	N. Mid. District.	London, C.T.O. Section	1-7-29
Wanless, G. G.	Inspector	Scot. E. District	E. District.	2-3-29
Prosser, G.	,,	N. Wales District.	E.-in-C.O.	17-3-29
Wilson, G.	,,	S. Wales District.	,,	18-4-29
Dalton, A. W.	,,	N.W. District.	S.E. District.	14-4-29

Retirements.

Name.	Grade.	Districts.	Date.
Gwilliam, W. J.	Executive Engineer.	Testing Branch.	30-3-29
Appleby, C. W.	,,	London.	31-7-29
Peck, G. A.	,,	Northern.	1-7-29
Patrick, J.	,,	Scot. E.	31-8-29
Chandler, A. E.	,,	E.-in-C.O.	31-8-29
Richardson, G.	,,	N. Wales.	30-6-29
Dickson, J.	,,	N. Wales.	30-6-29
Laslett, G.	,,	N. Ireland.	1-7-29
Wells, R. A.	,,	London.	31-7-29
Steed, H. P.	,,	,,	30-6-29
Hansard, A.	Assistant Engineer.	S. Mid.	31-5-29
Latimer, F. D.	,,	S. East.	14-3-29
Holland, C. G.	Chief Inspector.	N. West.	31-3-29
Stevenson, R.	Inspector.	Scot. West.	27-3-29
Wells, R.	Inspector (Wireless Overseer).	Scot. West.	15-4-29
Lynch, F. F.	Inspector.	London.	19-4-29
Lambert, R. B.	,,	S. East.	23-4-29
Patrick, D.	,,	Scot. East.	3-5-29

Deaths.

Name.	Rank.	District.	Date.
Knox, W. G.	Inspector.	S. Mid.	28-2-29
Brackley, L. P. A.	,,	S. East.	21-4-29
Jones. J. C.	,,	N. Wales.	16-4-29

CLERICAL ESTABLISHMENT.

Promotions.

Name.	Grade.	Promoted to.	Date.
Knapman, W. C.	Clerical Officer, London District.	Higher Clerical Officer, London Dist.	1-4-29
Paine, F. J.	Clerical Officer, London District.	Higher Clerical Officer, London Dist.	1-4-29
Adams, W. F.	Clerical Officer, London District.	Higher Clerical Officer, London Dist.	1-6-29
Peck, H. W.	Clerical Officer, S. Mid. District.	Higher Clerical Officer, N. Ire. Dist.	1-5-29

Retirements.

Name.	Grade.	District.	Date.
Copp, S.	Higher Clerical Officer.	London.	31-3-29
Swansborough, R.	Higher Clerical Officer.	London.	31-3-29
Jenkins, W. A. S.	Higher Clerical Officer.	London.	31-5-29
Bell, J. G.	Higher Clerical Officer.	Scotland East.	19-5-29

APPOINTMENTS.

Name.	From	To	Date.
Petche, E. A.	Clerical Officer, E.-in-C.O.	Asst. Supt. of Traffic, L.T.S.	16-3-29
Wilderspin, G. H.	Clerical Officer, E.-in-C.O.	Asst. Supt. of Traffic, L.T.S.	16-3-29

DRAUGHTSMEN ESTABLISHMENT.

PROMOTIONS.

Name.	Grade.	Promoted to	Date.
Payne, R. P.	Draughtsman, Cl. I., E.-in-C.O. (acting).	Draughtsman, Cl. I., E.-in-C.O. (substantive).	29-9-28
Wakefield, E. T. R.	Draughtsman, Cl. II., E.-in-C.O.	Draughtsman, Cl. I., E.-in-C.O.	14-2-29
Dale, R. A.	,, ,,	,, ,,	14-2-29
Ackland, W. E.	,, ,,	,, ,,	14-2-29
Lipscombe, C. A. D.	,, ,,	,, ,,	21-4-29
Horne, F. H.	,, ,,	,, ,,	14-2-29
Deacon, T. A. F.	,, ,,	,, ,,	14-2-29
Shipley, E. C.	,, ,,	,, ,,	14-2-29
Gill, O. W.	,, ,,	,, ,,	14-2-29
Allport, A. W.	Draughtsman, Cl. II., N. Wales Dist.	Draughtsman, Cl. I., N. Wales Dist.	1-1-28
Turver, S. C.	Draughtsman, Cl. I., Ldn. Engr. Dist.	Senior Draughtsman, Ldn. Engr. Dist.	14-2-29
Tait, W. D.	Draughtsman, Cl. II., Scot. E. Dist.	Draughtsman, Cl. I., Scot. W. Dist.	21-5-29
Grierson, A.	Draughtsman, Cl. II., N.E. Dist.	Draughtsman, Cl. I., N.E. District.	5-5-29
Thorpe, W. R.	Draughtsman, Cl. II., London Engineering District.	Draughtsman, Cl. I., Ldn. Engr. Dist.	14-2-29
Faulkner, L.	Draughtsman, Cl. II., S.E. Dist.	Draughtsman, Cl. I., Ldn. Engr. Dist.	22-5-29
Thomas, E. W.	Draughtsman, Cl. II., S. Wales Dist.	Draughtsman, Cl. I., S. Lancs. Dist.	16-6-29

APPOINTMENTS.

Name	From	To	Date.
Craft, L. W.	Draughtsman, Unestd., E.-in-C.O.	Asst. Supt. of Traffic, Cl. II., L.T.S.	25-8-28
Tyzack, W. E.	Draughtsman, Unestd., E.-in-C.O.	Asst. Supt. of Traffic, Cl. II., L.T.S.	18-3-29
Hill, F.	Draughtsman, Cl. I., E.-in-C.O.	Architectural Asst., Grade II., Secretary's Office.	29-9-28
Devey, G. B.	Draughtsman, Cl. II., E.-in-C.O.	Probationary Inspector, London Dist.	1-1-29
Stevens, P. F.	Draughtsman in Training, E.-in-C.O.	Probationary Inspector, E.-in-C.O.	20-1-29

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All Remittances and Communications should be addressed to the Managing Editor, P.O.E.E. Journal, Engineer-in-Chief's Office, Alder House, London, E.C.1.

Binding covers and copies of the Contents for Vol. 3 to 20 are available, and may be obtained from the local agents for 1*s*. 6*d*. and 3*d*. respectively. Subscribers can have their copies of Vol. 21 bound, with index included, at a cost of 3*s*. by sending the Journals to the local agents. Orders for bindings, Vols. 1—19, should indicate whether the original binding with black lettering, or the later pattern in gold, is required. Covers with gold lettering will be the only type stocked from Vol. 20 onwards.

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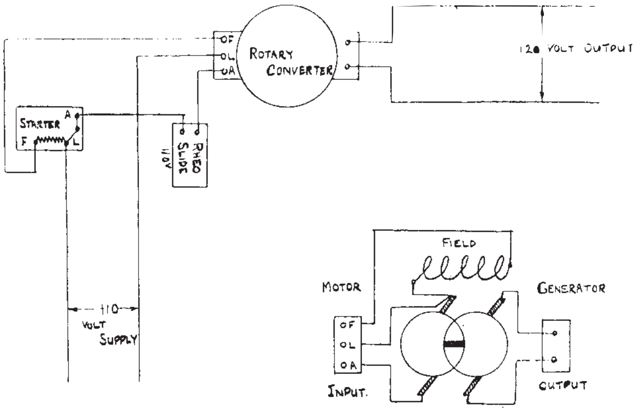
THE
Post Office Electrical Engineers' Journal

LOOP WORKING FROM ROTARY CONVERTORS OR MOTOR GENERATORS.

J. H. Hart, A.M.I.E.E., C.T.O.

It has been the aim of all Telegraph Engineers to work circuits from power generators, but the conditions have, in most cases, compelled them to use Primary or Small Secondary Cells.



Rotary Converter
D.C for Loop Working.

Fig I

Where small telegraph installations exist, the economic conditions are such that Primary Cells are without doubt cheapest. In other cases Secondary Cells hold sway, but there is, without question, a field for the Motor Generator to supply current for Telegraph purposes, particulary when Loop Circuits are installed. At the Central Telegraph Office, owing to space restrictions, the employment of Cells became a serious matter, and it was felt use might be made of machine units. An experiment was carried out during the War on TS-AB3, and use was made of a Rotary Convertor, rather large for the work required. The machine ran for three years without complaint and justified a further trial of machines more suitable for the purposes required. To this end three machines were obtained during the early part of 1924, one

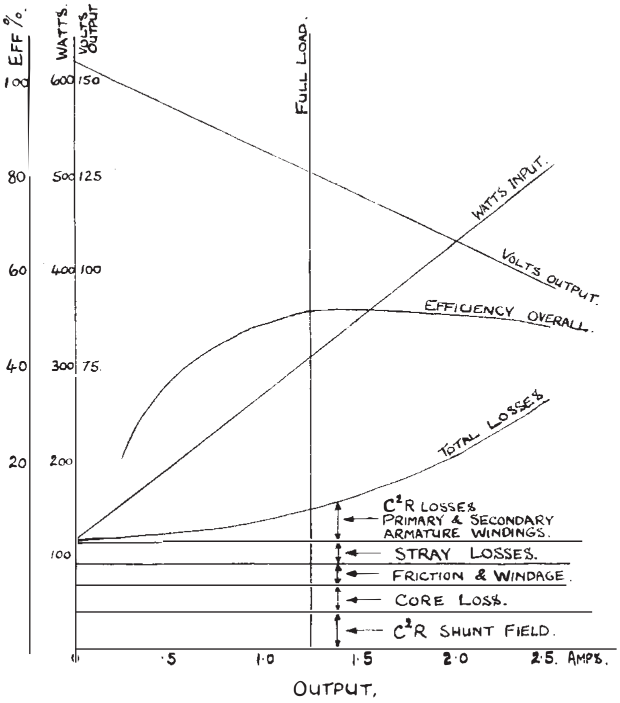


Fig. 2.—Characteristics of Machines in use.

from the Small Power Dynamo & Motor Co., of Manchester, another from Messrs. Ward & Goldstone of the same city, and a third from the English Electric Co. Trials and tests were made with these machines under varying conditions, and, ultimately, it was agreed that all new Loop installations should be worked by means of Rotary Convertors. At present 54 of these machines are in use, and, unless some new scheme of working is evolved, it would appear that the replacement of all Small Secondary Cells by Rotary Convertors or Motor Generators is not distant.

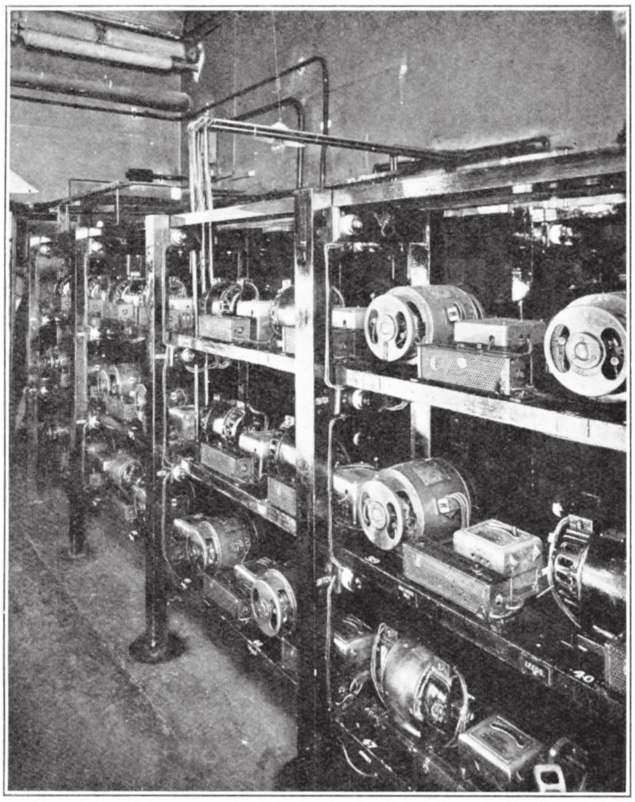


Fig. 3.—Part of Installation at C.T.O.

The machines are compact; there is no low insulation brought about by "creeping" of acid on the power leads, and the relative number of complaints of "Battery" failures has become proportionately less.

The types of circuit on which the machines work are as follows:—

Baudot Circuits ...	12.	Chiefly Autoplex.
Wheatstone—Creed ...	8	
Teleprinters (Duplex)	5	
Other circuits	7	

It will, of course, be appreciated that two machines are necessary where Telegraphs of the Baudot types are concerned.

A description of the type of machine used by the Post Office will be of interest. There is only one "Field" to the machine, but there are two insulated windings on the Armature and of necessity two Commutators for Motor and Generator respectively. A sketch of the connections is given in Fig. **1**.

The machines obtained, for the Central Telegraph Office, have a rated input of 110 volts D.C. and output of 120 volts at 1.25 amperes full load. A slow rotational speed has been aimed at, and they are run at 1,200 r.p.m. A characteristic chart of the machine which is in general use is given in Fig. **2**.

It may be asked why so large an output has been arranged for. One of the reasons is that a commercial machine that needed little change from the standard type of the makers was adopted; another is that stability of voltage conditions is essential.

A photograph of part of the installation at C.T.O. is given in Fig. **3**.

A further possible lay-out is given in Fig. **4**. This shows the machine askew which enables the commutators to be cleaned easily, if the machine is installed near a wall.

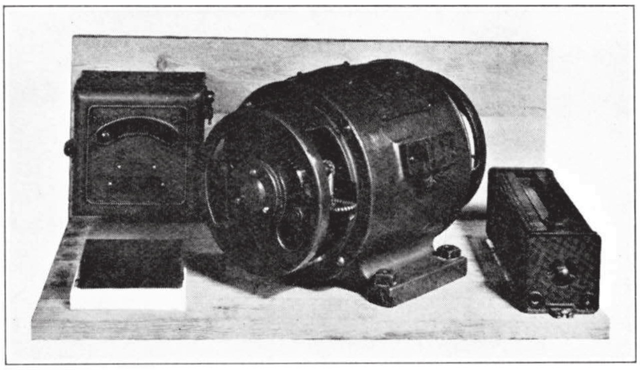


Fig. 4.—Alternative Method of Mounting Machines.

It will be of interest to state that the Cable Telegraph Companies also use Motor Generators, or Rotary Convertors for current purposes. The Eastern Telegraph Co. use a similar machine and the Western Union Co. use a Motor Generator which consists of three parts: (*a*) the Motor, (*b* and *c*) two Generators, one for Positive and the other for Negative supply. The latter machine is specially made for the Company.

TELEGRAPH REPEATERS. THE NEUTRAL RELAY.

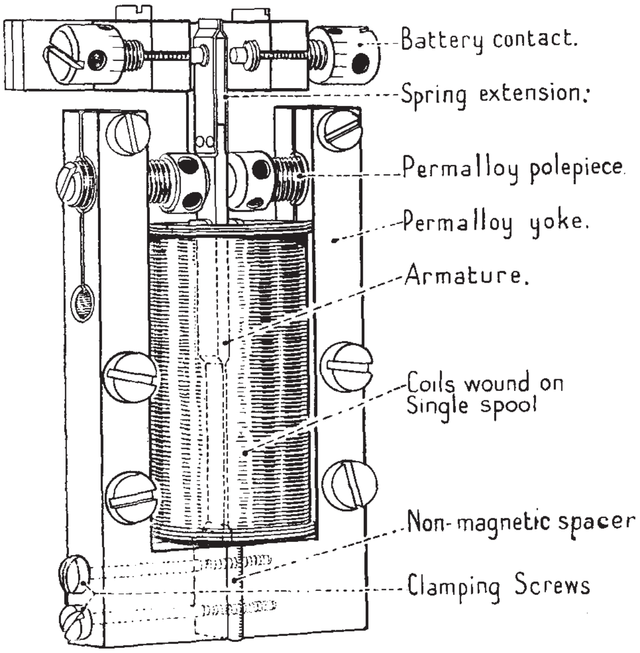
R. P. Smith.

IN this Journal of July, 1926, Mr. E. Lack referred to the difficulties experienced in simplex working on fast speed telegraph repeaters and described a method of minimising the trouble. A simple and effective remedy has now been provided by the introduction of the Western Electric Relay F.A. 109, adjusted to function as a neutral relay for closing the automatic switch. Due to the method of construction, the armature of the Post Office standard relay cannot take up a neutral position between the polepieces of the electromagnets, consequently controlling springs are necessary when it is required to keep the tongue in a position clear of both battery contacts. The springs, however, result in a loss of sensitivity since their tension has to be overcome. The armature of the Western Electric relay is placed in a nonmagnetic spacer at one end and then clamped between two yoke extensions of the permanent magnets as shown in the accompanying figure.

It acts in a similar manner to a vibrating reed, as the tongue extension is capable of taking up a neutral position between the two contacts when suitable adjustments are made. The yokes, armature, and polepieces of the relay are permalloy and the mass at the moving end of the armature is small; consequently the operating current required is low. A standard relay, fitted with spring extensions to the tongue has been adjusted to repeat signals at slow speed with an operating current of 0.043 mA and the W.E. Relay with 0.033 mA.

The permeability of permalloy is high at low induction densities and residual effects small, with the result that there is no polarising effect on the W.E. Relay when using the normal telegraph working currents. The standard relay is somewhat troublesome in this respect and close attention is necessary in fast speed Wheatstone working to counteract the variable bias arising from polarisation of the cores. The Research Section discovered that the defect was due to the method of annealing the cores of standard relays causing a carburized sheath to form round each. A new process, by which the cores are annealed in hydrogen gas has been adopted, giving good results. Cores annealed by the new method are stamped " GAS A " at the upper end, the marking is visible through the glass cover of the relay.

The Western Electric relay functions equally well either in a vertical or a horizontal position. It may be of interest to mention that a recent investigation of the operation of the standard relay showed its sensitivity to be greatest when the relay is in a horizontal position with the armatures pointing upwards. A relay adjusted to repeat signals with a minimum current of 0.2 mA when in a vertical position will function equally well with 0.12 mA when in the horizontal position stated. If the relay is in a horizontal position with the armatures pointing downwards, it is slightly less sensitive than in a vertical position. The explanation appears to be that the spindle has a clearance in its two bearings giving room for movement, particularly in the case of relays that have seen considerable service,



Western Electric Neutral Relay.
The method of mounting the relay is not shown.

where the play may amount to several mils. In the horizontal position, with armatures pointing upwards, the spindle rests in the bearings above the poles of the permanent magnet, consequently, the armatures are at a point where the magnetic field is more intense than when the armatures and spindle fall to the opposite side of the bearing.

The contacts of the Western Electric relay tongue are attached to two nickle-silver springs rivetted to the armature; the springs are bent at the free end to rest upon one another with a certain pressure. Under these conditions the make and break of the contact is remarkably accurate, and chattering is reduced to a minimum, rendering the relay particularly useful from the telegraph repeater point of view. It has been found, experimentally, that the relay will function quite satisfactorily as a neutral relay when transmission is at the speed limit of a given line.

The coil ends of the Western Electric Relay are terminated on pins carried by the base of the relay. The instrument is intended for panel mounting on a rack, a mounting block fitted with spring contacts being employed to engage the pins on the relay when it is placed in its working position. When the relay is used for a Telegraph repeater in this country a small wooden box fitted with standard relay terminals carries the mounting block. Permanent connection is made between the terminals and springs by wiring inside the box.

The availability of a highly sensitive neutral relay opens up a prospect of economy in other directions. Where a line relay has a Creed or Wheatstone receiver in its local circuit a voltage is required on the spacing and marking contacts, hence, during periods when the circuit is idle, current is wasted. If a neutral relay were employed, there would be no current in the local circuit during idle periods, economy in current would result, and the necessity for a switch in the spacing battery lead would be avoided.

THE MENDONCA D'OLIVEIRA GOVERNOR FOR BAUDOT DISTRIBUTORS.

THIS Governor, known as Distributor, Baudot, No. 4, is based on the principle of a slipping clutch. That is to say, somewhat more power than that required is provided for driving the instrument, which has a device to release the drive as soon as the speed begins to exceed that required and also to restore the drive as soon as the speed has dropped to the correct value. This de-clutching and clutching action soon adjusts itself to a more or less partial slipping action, just taking sufficient grip to drive the mechanism at its correct uniform speed. On this account the voltage of 110 usually applied to the driving motor can be allowed to vary between 70 and 120 without causing sufficient variation of speed to interfere with correct working.

The driving unit consists of a cast iron frame C (Fig. 1), containing a small A.C. or D.C. motor M rated at 1/20th H.P., 3500 revolutions. The drive is transmitted by means of a twisted cotton belt, which can be tightened when necessary by an adjusting nut working on a screw from one side of the plate supporting the motor, the other side of the plate being hinged to the main frame C.

An extension of the main axle A passes through and is keyed to a steel sleeve F. Two hollow steel arms EE are pivoted at DD on a cross-arm forming part of the steel sleeve F. The other ends of the arms are fitted with cylindrical wooden friction pieces which are pressed on to the conical extension of the pulley P by two pairs of strong steel springs SS. The cone and pulley are free on the axle A, but are driven by the twisted cotton belt.

The power of the motor is thus transmitted through the clutch and governor to the axle A and its extension, which gears with the intermediate wheel of a standard Baudot Distributor train placed on the main frame C. The speed of the governor can be varied by adjusting the tension of the springs SS, by altering the position of the friction pieces on the cone, and by altering the position of the sliding weights W (Fig. **2**).

For checking the correct adjustment of the tension of the springs S,S, two bosses are provided at the ends of the governor arms. When this has been done, it may still be necessary to slightly alter the positions of the weights W to obtain a final small adjustment. During these adjustments the position of the wooden friction pieces should be half-way along the face of the cone. There will then be a speed range by means of the adjusting screw R, of approximately fifteen revolutions of the Distributor brush arms, on each side of the normal speed.

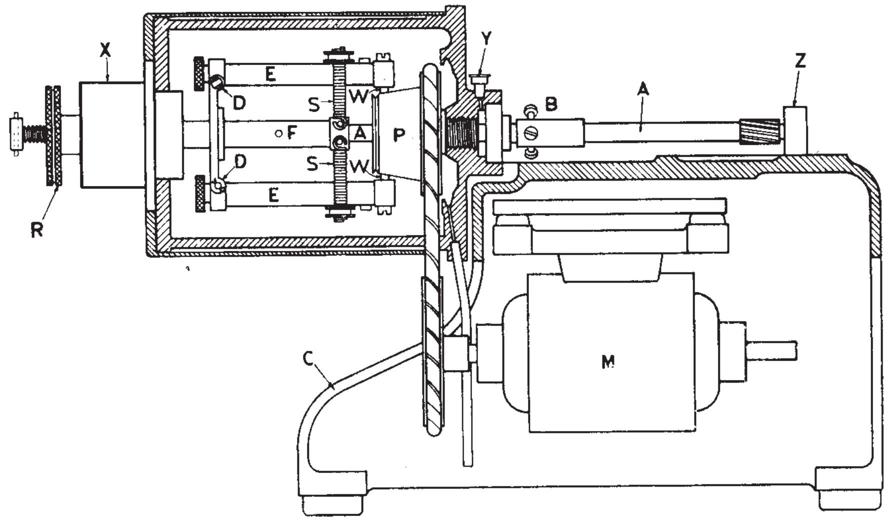


Fig. **1**.—Distributor, Baudot No. 4.

When the motor is started the governor rotates at the same speed as the pulley P. As the speed increases, the centrifugal force acting on the governor arms in opposition to the springs SS, also increases, thereby reducing the pressure of the friction pieces on the cone. At a critical speed, the friction pieces commence to slip, thus preventing any increase of speed of the distributor brush arms. So long as the speed of the motor does not fall below this critical value, it may vary fairly considerably above it without causing any difficulty.

The governor enables a constant speed to be maintained, but does not overcome the necessity for the use of the usual Baudot epicyclic correcting gear, which is required to keep two distributors in correct phase relationship.

The advantages of the Mendonca D'Oliveira governor are as follows:—

1. It is a self-contained unit.
2. It is unaffected by variations in the power supply of approximately 40%.
3. Small variations of speed can be made without stopping the distributor.

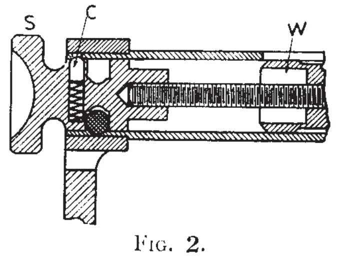


Fig. **2**.

A number of these governors have been purchased to replace phonic-wheel distributors, the driving reeds of which are rather susceptible to small changes of the driving voltage.

METROPOLITAN AND NATIONAL EXCHANGES.

W. R. TYSON, B.Sc., A.M.I.E.E., and F. E. TETLOW.

AN interesting ceremony was performed on Saturday, August 13st, 1929, when the new METropolitan Director exchange was cut into service in the presence of Col. Sir Thomas Purves, Engineer-in-Chief, G.P.O.; Col. A. G. Lee, Assistant Engineer-in-Chief, G.P.O.; W. F. Benoist, President, Automatic Electric Inc.; E. A. Mellinger, Director A.T.M. Co.; G. W. Moore, Director and Manager A.T.M. Co.; A. F. Bennett, Chief Engineer, A.T.M. Co.; and other distinguished visitors. NATional Director exchange, which is in the same building, was opened on the 7th September. Approximately 3,300 lines were brought into service in each case at these initial transfers. The manual exchanges being relieved are City, Central, London Wall, Clerkenwell and Avenue.

The exchanges are housed in a specially designed building in Wood Street, having a capacity for three ten thousand line units. The third exchange, which is not as yet required, will be called Empire. The equipment was manufactured and installed by Messrs. Automatic Telephone Manufacturing Co., Ltd., and installation of the main equipment was commenced in March, 1928, the installation covering approximately fifteen months. To allow of early termination of external cables, the Main Distributing Frames were installed in advance.

Building. The building has six floors and a basement. The floors are of reinforced concrete, those supporting heavier apparatus having the slabs reinforced by $4\frac{3}{4}$in. by $1\frac{3}{4}$in. filler joists at 2′ 0″ centres supported on 16in″ by 6″ by 62 lbs. concrete-filled I beams across the building, and 12″ by 8″ by 65 lbs. concrete-filled I beams along the building.

The layout of the floors is as follows:—

Basement. Cable Chamber. Yard. Stores.

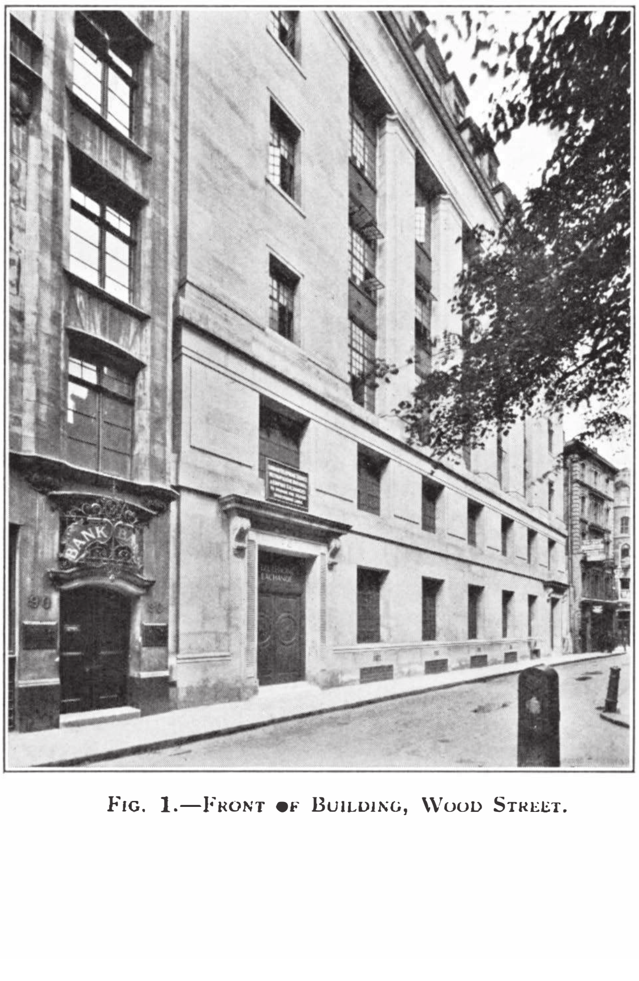
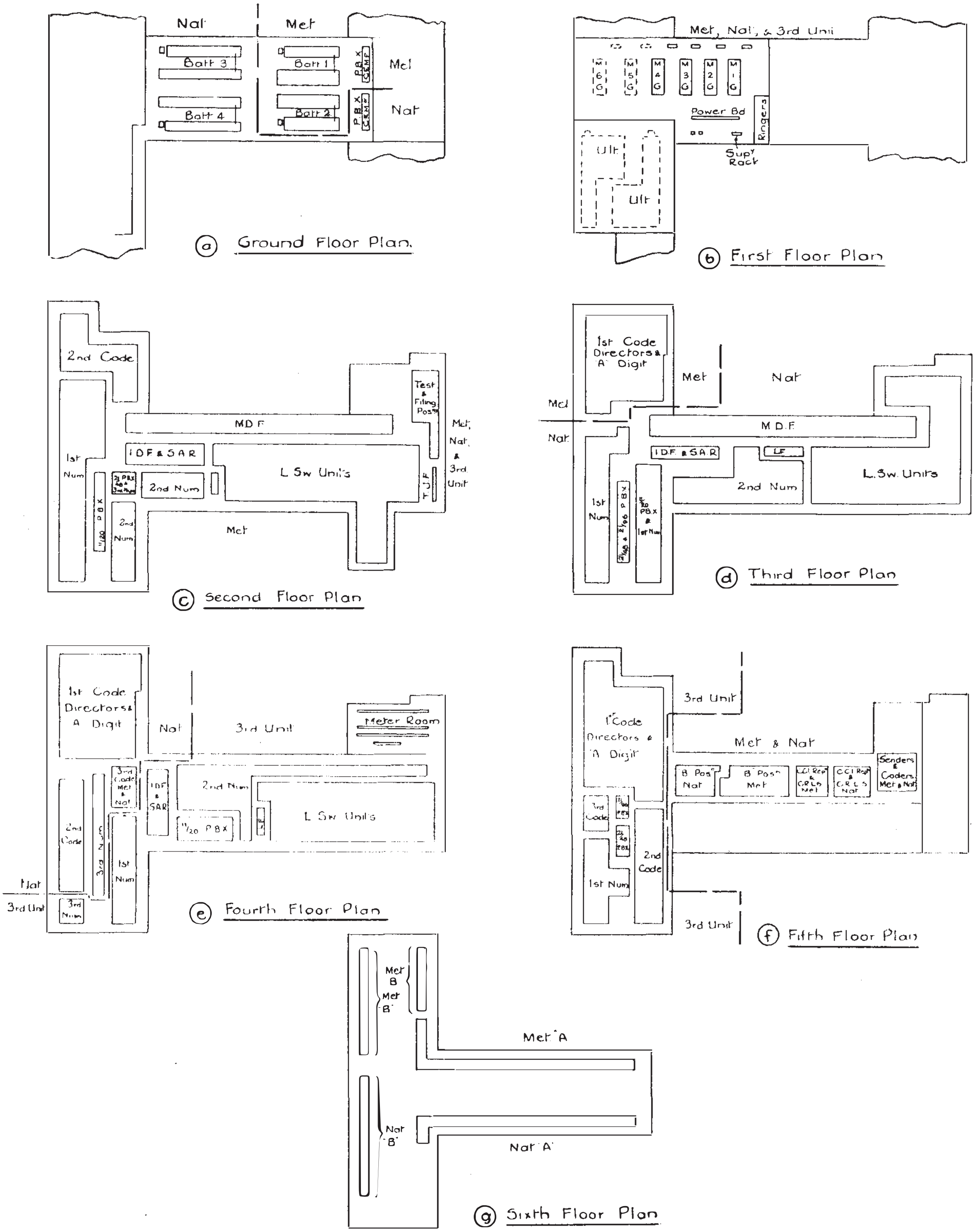


FIG. 1.—FRONT OF BUILDING, WOOD STREET.



(a) Ground Floor Plan.

(b) First Floor Plan

(c) Second Floor Plan

(d) Third Floor Plan

(e) Fourth Floor Plan

(f) Fifth Floor Plan

(g) Sixth Floor Plan

FIG. 2.—METROPOLITAN AND NATIONAL EXCHANGES. SKELETON FLOOR PLANS.

Ground Floor. Metropolitan and National Batteries. Stores.

First Floor.—Metropolitan and National Machines and Power Board. Ultimately Empire Machines, Power Board and Batteries; Lineman's Rooms and Offices.

Second Floor. Part M.D.F. for MET, NAT and EMP, MET IDF, Line Switch and Final Selector Units, Group Selector Racks and Miscellaneous Equipment. Metropolitan, National and (ultimately) Empire Test Desks and Test Jack Frames.

Third Floor. Remainder of M.D.F. for MET, NAT and EMP, NAT IDF, Line Switch and Final Selector Units. Numerical Selector Racks and Miscellaneous equipment, Metropolitan Directors and First Code Selectors.

Fourth Floor. Subscribers' Meters for Metropolitan and National and (ultimately) Empire. National Directors, First Code Selectors, etc. Room for Empire IDF, Line Switch and Final Selector Units, and Numerical Selectors. A Centralised Service Observation Desk and Equipment for Observations on all London exchanges has also been installed on this floor by the Department.

Fifth Floor. Metropolitan, National and (ultimately) Empire Junction Apparatus Racks, CCI Repeaters, Coders, Senders and Service Interception equipment. Offices.

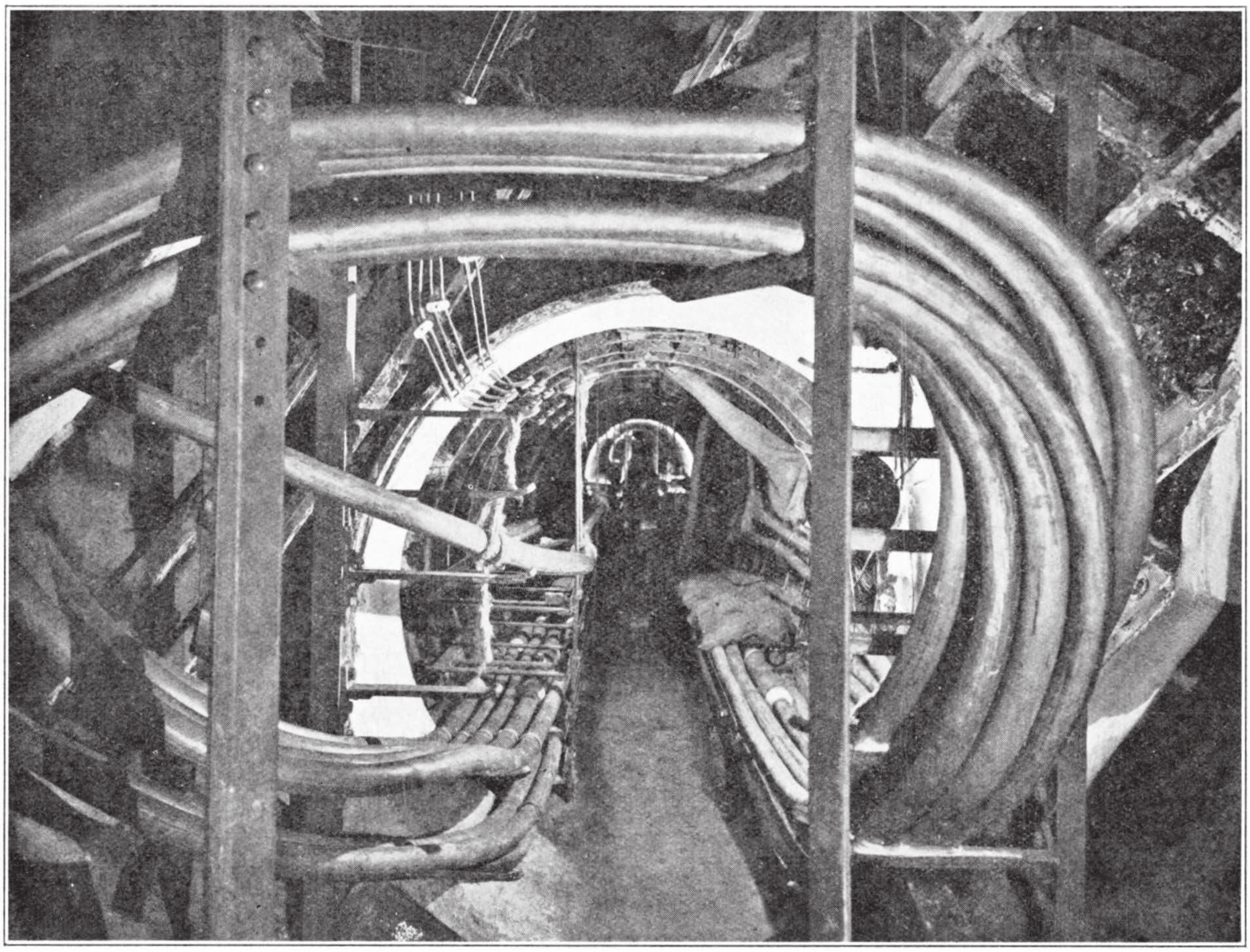


FIG. 3.—CABLE TUNNEL.

Sixth Floor. Manual Equipment (" A " and keysender " B " positions, and Supervisor's Desks).

Fig. 2 gives an indication of the layout of equipment on the various floors.

A description of the tunnel through which cables are brought into the exchange is contained in the I.P.O.E.E. Journal for April, 1926 (Vol. 19, page 43), under the title "Guildhall Exchange Tunnel." (It was originally intended that Metropolitan exchange should be called "Guildhall"). From the cable bearers at the head of the tunnel, cables are taken through vertical pipes laid in the wall of the building, to trenches on the second and third floors for the Main Distributing Frames.

Access to the building for apparatus is afforded by a large goods entrance in Silver Street and a goods lift, capable of carrying 6 tons, carried the equipment to the yard in the basement, whence it was lifted to apparatus entrances on each floor by means of a 5 HP. 30 cwt. electric hoist working to a jib fixed over the apparatus entrances.

The plenum system of ventilation is used throughout the building, the pump and fan rooms being in the basement.

Main Distributing Frames. As indicated above, there are two Main Distributing Frames, one on the second floor and one on the third floor. The Frame on the second floor accomodates on the Exchange Side all junctions incoming to and outgoing from the three exchanges, and all the Metropolitan subscribers' lines. On the third floor, accommodation is provided initially for National subscribers' lines, and provision is made for extending the frame to serve the Empire subscribers' lines. The second frame is vertically above the first, and pipes are run through the floor (one pipe per MDF vertical) for jumpers running between the two frames. Additional jumper rings are interpolated in suitable positions to facilitate the running of such jumpers. The first MDF has

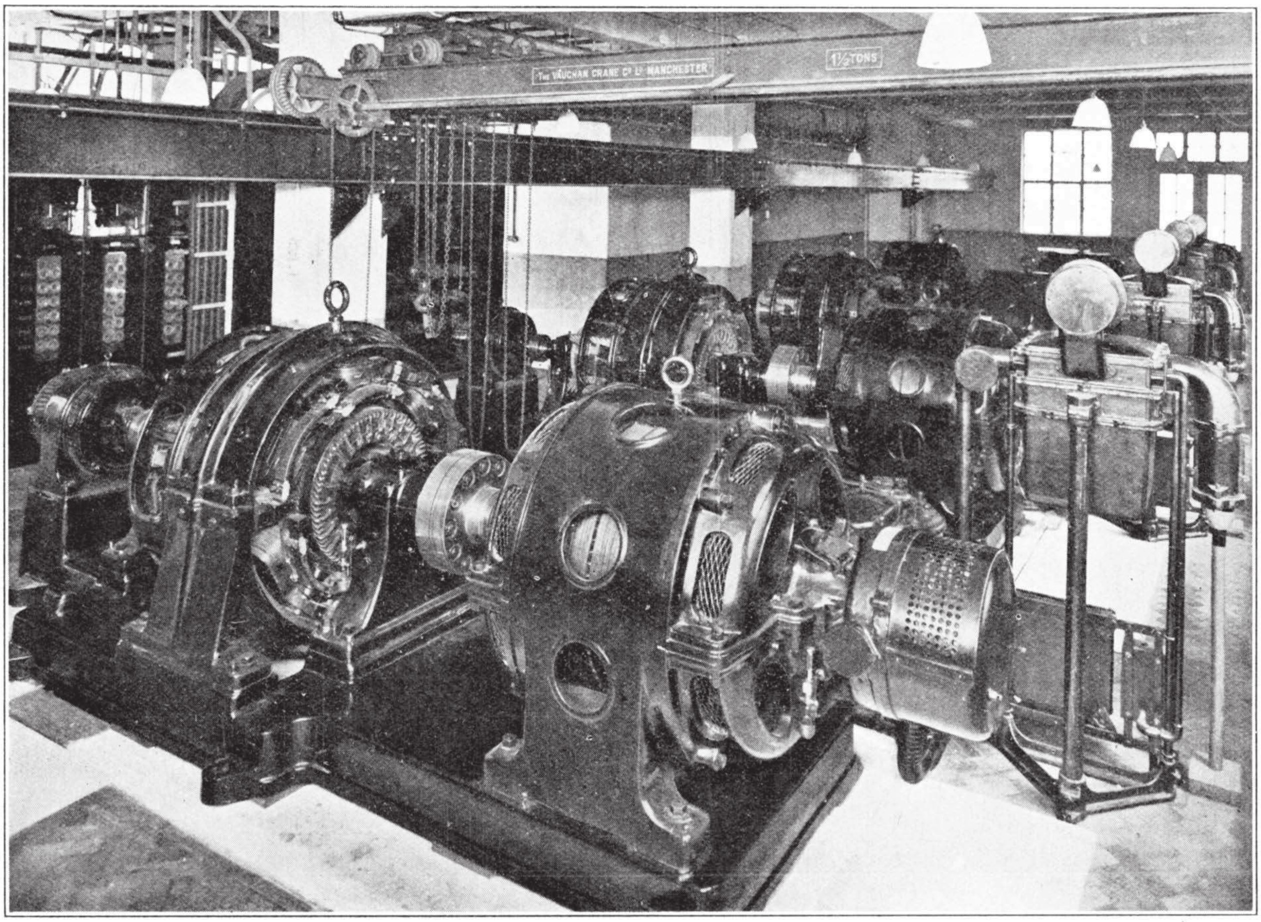


FIG. 4.—MOTOR GENERATORS.

177-200/220 circuit verticals, giving a length of almost 100 feet, and is served by four travelling ladders on each side. The second MDF has an initial length of 115-200/220 circuit verticals, with provision to grow as long as the first MDF., and is served at the outset by two travelling ladders on each side.

Test Desks. The Test Desks for Metropolitan and National, and space for those for Empire are situated on the second floor near to the commencement of the M.D.F. Initially, there are fourteen Testing Positions and seven filing positions for the first two exchanges. These are arranged as follows:—

Subscribers' Testing. The Metropolitan and National Subscribers' Test Desks are in one suite; there are Five Testing positions and Two Filing Sections particular to each exchange; the central Filing Section of the suite is common to both exchanges. Standard testing facilities are provided. Arrangements have been made for any Test Clerk to have access to subscribers' lines on both exchanges.

Junction Testing. Two Testing sections and one Filing Section are provided and are common to both exchanges.

Advice Note Testing.—Two Testing sections and one Filing Section are provided common to both exchanges. Eighty circuits for testing new subscribers' lines are taken from these positions and multiplied at intervals along both M.D.F.'s.

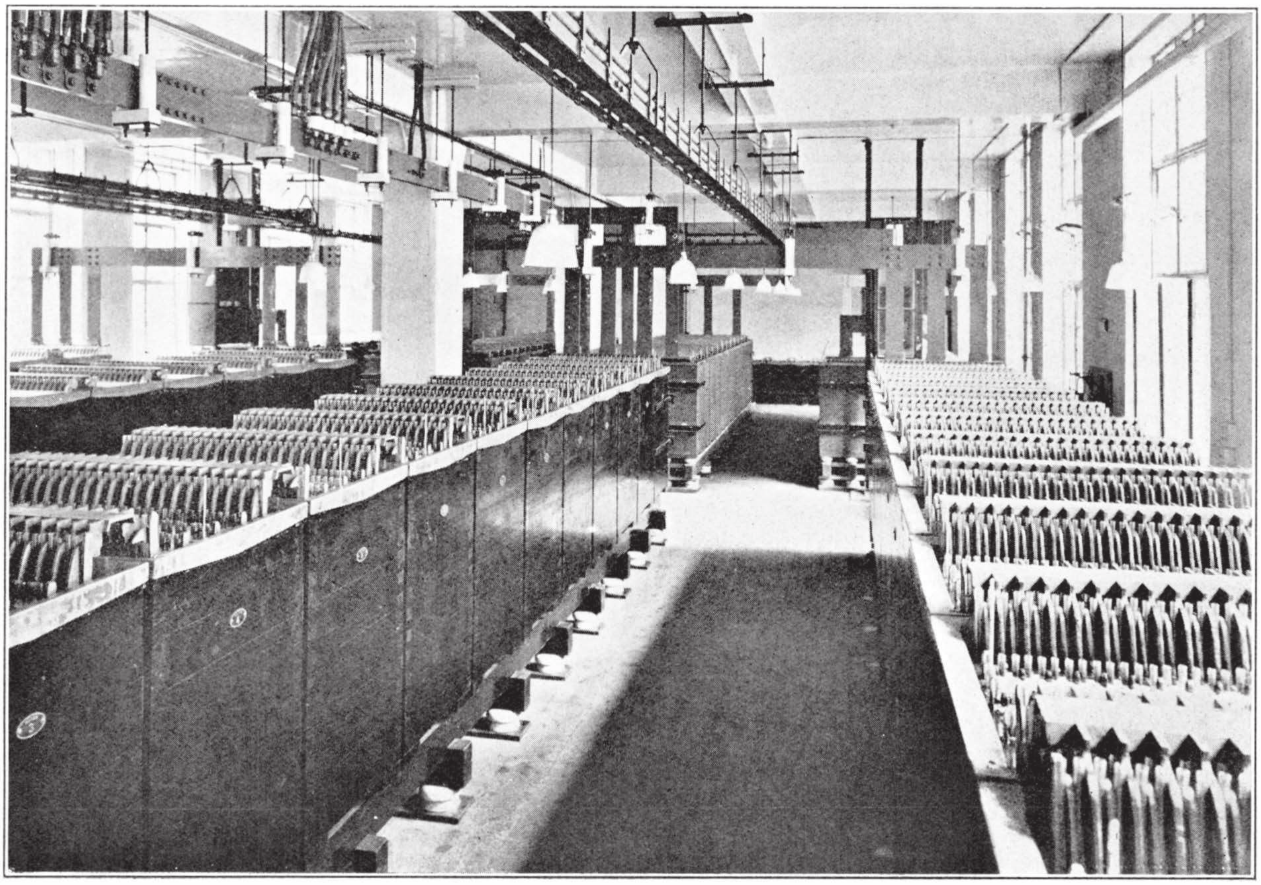


FIG. 5.—BATTERY ROOM, SHOWING BUSBARS AND CABLES.

A Test Jack Frame of 6 bays, having a capacity of 4000 tapping jacks for outgoing junctions, is installed between the Subscribers' Test Desk and Junction Test Desk. There is space for 3 more bays for the Empire Outgoing Junctions when required.

Power Plant. The power supply to the building is 11,000 volts, three-phase, 50-cycle A.C.

This is transformed down to 400 volts at a substation situated in the basement. Four motor generator sets (two for each exchange), each consisting of an autosynchronous motor direct-coupled to a D.C. generator, have been installed for charging the batteries. The manufacturers are Messrs. Crompton, Parkinson & Co. The motors are 400-volt, 3-phase, 50-cycle and can be adjusted by means of direct coupled exciters to give unity power factor at any load. The generators each have an output of 1600 amps at 57 volts. The speed of the sets at full load is 600 r.p.m. and guaranteed efficiencies are 82% at full load and 78% at half load. Space has been left for two further similar motor-generator sets required for Empire.

Four batteries of 10,000 ampere-hours at the 9 hour discharge rate, each consisting of 25 cells, have been provided. The two for Metropolitan were manufactured and installed by the D.P. Battery Co., and those for National by the Alton Battery Co. The cells are over four feet in height, and the total weight of the four batteries is 210 tons when filled with acid.

Normally, one common power discharge lead serves both exchanges, and will also ultimately serve Empire. Provision has been made on the power switchboard for running one or more machines in parallel with one or two of the batteries in case of unforeseen demands.

An overload circuit-breaker with delay feature has been provided in circuit with each main battery and will function in case of a serious short-circuit.

Connections between batteries and the power switchboard is by means of heavy copper bus-bars, and the distribution fuseboards serving the automatic plant are fed by V.I.R. cable.

A 400-volt supply-driven ringer, and a battery-driven ringer are supplied for each exchange. These were manufactured by Messrs. Newton Bros., Derby. In case of breakdown of the supply-driven ringer through any reason, facilities have been provided for automatic changeover to the battery-driven ringer. The output of the ringers is 4 amps. at 75 volts with a rise to 95 volts at no load, and the guaranteed effiiciences are 60% at full load and 50% at half load.

In addition to the A.C. supply to the building there is a 200 volt D.C. supply for working the lifts.

Automatic Plant.

The following is a list of the main items of the Automatic equipment :—

	Metropolitan.			National		
	Racks	Banks and Wiring	Switches	Racks	Banks and Wiring	Switches
Subscribers' Rotary Lineswitches ...	95	9500	9500	91	9500	9500
P.B.X. 2-10 Final Selectors		2296	1827		2096	1572
P.B.X. 11-20 Final Selectors	2	240	136	4	660	308
P.B.X. over 20 lines	22	100	78	7	300	235
Test Final Selectors	—	104	104	—	114	112
Trunk Offering Final Selectors ...	—	100	100	—	103	101
Test Distributors	1	12	11	1	12	11
Trunk Offering Distributors		10	10		10	10
1st Code Selectors	9	1340	1277	10	1560	1460
A digit Switches	1	180	167	1	190	165
Directors	15	280	246	16	280	238
2nd Code Selectors	7	1400	1257	7	1400	1277
3rd Code Selectors	4	480	306	(included with Metropolitan)		
1st Numerical Selectors	12	2280	1868	13	2480	1903
2nd Numerical Selectors	10	1700	1606	11	2040	1668
3rd Numerical Selectors	1	80	55	2	300	180
C.C.I. Repeaters and Coder R.L.S. ...	11	1080	992	7	700	610
Coders	2	80	80	2	80	64
Sender (4 digit)	2	80	74	2	60	60

The subscribers' Multiples are : Metropolitan —10200, National—10400.

Owing to the large number of P.B.X's. to be served by the exchanges, the whole of the final selectors on the Line Switches and Final Selector units are of the P.B.X. 2—10 type, which caters for single lines and small P.B.X's. up to 10 lines; the multiple is split in the standard man-

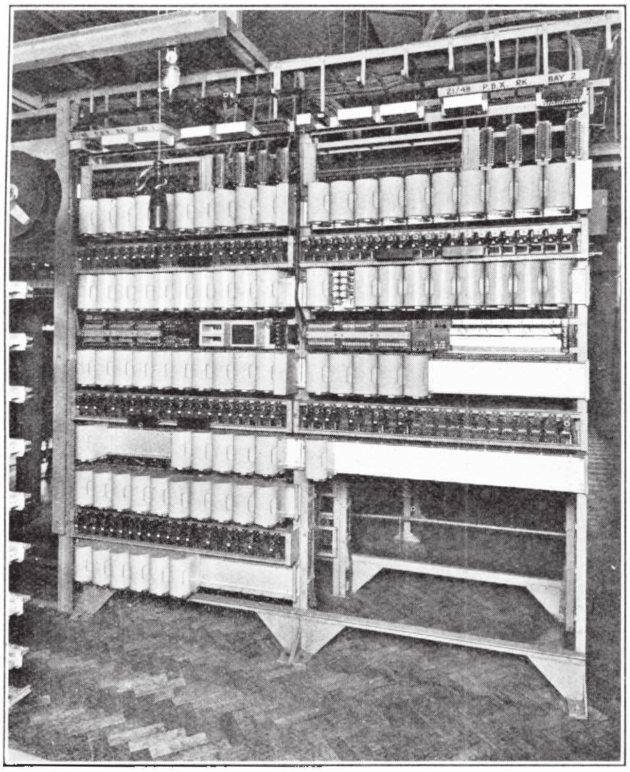


FIG. **6**.—P.B.X. 21—48 FINAL SELECTOR RACK, SHOWING UNIVERSAL PRESSED STEEL CHANNEL TYPE SHELVES.

ner to allow for temporary growth of a P.B.X. over 10 lines without changing the subscriber's number. The number of P.B.X's. over 10 lines on National being abnormally large, it was found necessary to fit 4 of the Line Switch units with rotary line Switches on each side, the whole of the 800 switches on these units being cabled to the I.D.F. for cross-connections to the relevant large group final selectors.

The First Code Selectors are of the 10-circuit per level type; the whole of the Group Selectors have 20 circuits per level. These switches are all fitted on the well-known double sided type racks.

It will be noticed that Third Code Selectors for both exchanges have been accommodated on common racks. This is so that outgoing junction *via* Third Codes may be in common groups. These junctions are, for the most part, small groups to the more distant exchanges, and the commoning therefore provides for one larger junction group instead of two smaller junction groups and since the former has a larger traffic carrying efficiency than the latter, an economy in switches has been effected. This commoning of groups has made it possible to route many junctions direct instead of *via* Tandem.

To provide for testing auxiliary lines (*i.e.*, lines outside the ordinary numbering) an auxiliary Test Distributor is fitted for each exchange.

The P.B.X. 21—48 final selectors each consist of a relay set associated with a 50-point Rotary Line Switch, the P.B.X. 21—96 Final Selectors each consist of a relay set associated with two 50 point Rotary Line Switch in tandem. These are fitted on single-sided racks, fitted with the new A.T.M. pressed steel channel type shelves, which can be universally employed for mounting all types of automatic jack-in switches and relay sets (see Fig. **6**). The Department is proposing to adopt the idea of pressed steel channel type shelves as standard for all jacked-in Automatic equipments. The apparatus for junctions incoming from Manual Exchanges to Key-sender "B" positions, and C.C.I. Repeaters and Coder Rotary Line Switches are similarly mounted on single-sided racks.

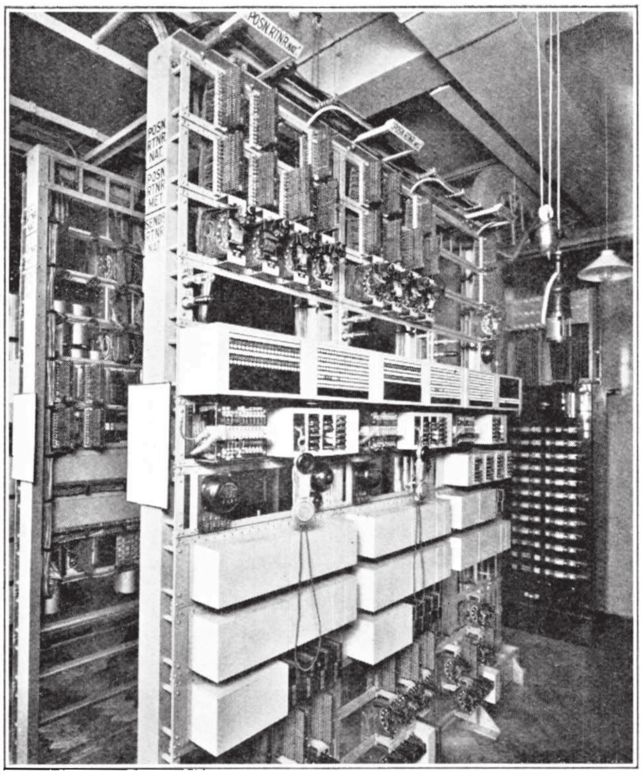


FIG. **7**.—AUTOMATIC ROUTINERS, FIFTH FLOOR, SHOWING FEEDER FUSE-BOARD FOR THIS FLOOR.

It is of interest to note that since the Junction Apparatus, C.C.I. Repeaters, Coders and Senders for both Metropolitan and National are concentrated in a comparatively small space on the 5th Floor, there are no fewer than 8 Automatic Routiners (one per exchange for each of the above types of equipment) on this floor. It is unusual to find so many Routiners in such a small area.

Alarm Scheme. To facilitate the rapid tracing of faults, a comprehensive system of floor alarms has been installed on the so-called "Geographical" basis. Each floor is divided into a number of main sections and sub-sections; a main section covering roughly 2500 square feet of floor area and a sub-section roughly 700 square feet. When a fault occurs (such as the blowing of a fuse, or the abnormal holding of a switch) the following conditions are set up:—

(1) A lamp centrally situated in the particular sub-section affected will glow.

(2) A bell situated in the section affected, rings.

(3) A panel centrally situated on the floor on which the fault occurs, is illuminated, and shows which main section is affected.

(4) A floor lamp panel multipled over all floors except the affected one, is illuminated, and shows to maintenance officers on other floors that a fault exists on the floor indicated.

(5) A floor alarm bell rings on all floors.

On each automatic rack a number of pilot lamps are fitted which indicate the type of fault and the particular shelf on which the fault exists; in certain circumstances the supervisory lamp on the faulty switch or relay set will also glow, so that when a fault has been traced to a specific subsection, it is a comparatively easy matter to locate it.

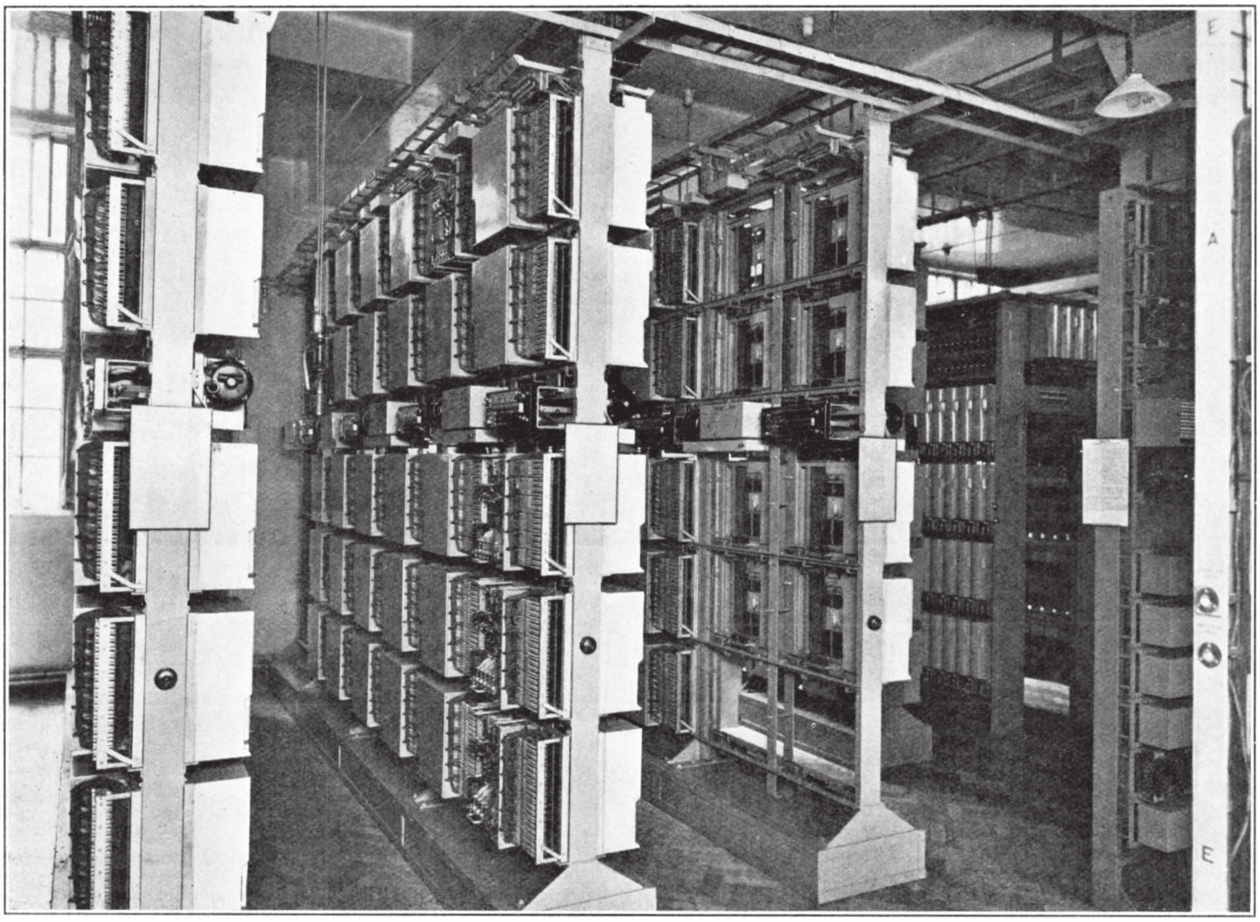


FIG. 8.—METROPOLITAN DIRECTORS.

By means of a Key on the Test Desk, alarms can be extended to the Manual Board during slack periods and at night time, and another Key on the Test Desk provides for cutting off the floor bells during busy periods when maintenance officers will be on all floors, and allowing only the section bells to ring. The visual signals are not affected.

Manual Equipment. The Manual Equipment installed initially is as follows: —

	Metropolitan	National
Service P.B.X. positions ...	1	—
Supervisor's positions	3	—
Enquiry & Interception positions	42	42
Keysender " B " positions ...	31	21
Supervisor's Desks	2	1
Fault Operator's Tables ...	1	1

The Service P.B.X. and Supervisor's positions shown under heading " Metropolitan " will serve both exchanges. The remaining Manual equipment is of the standard Director exchange type, and presents no unusual features.

This installation is of particular interest since it is the largest Automatic undertaking of its kind installed in this country as yet. It has only been possible to give a brief description of the installation; there have been many problems of a widely varied nature that have had to be solved, but their interest is particular rather than general and their description does not, therefore, come within the scope of this article.

Thanks are due to Messrs. Automatic Telephone Manufacturing Company, Ltd., for the loan of the photographs.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT, AS AT 30TH JUNE, 1929.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
638,958	526	3,968	52,307	125	London	24,937	79,742	2,464,143	120,512
83,309	2,153	21,021	67,296	2,411	S. East	4,055	54,471	227,825	27,235
86,688	4,483	31,385	59,455	3,511	S. West	21,322	13,426	166,240	58,522
68,636	6,096	38,556	62,191	4,471	Eastern	24,308	41,572	139,714	67,420
101,403	8,645	45,369	60,723	3,955	N. Mid.	32,114	55,932	255,926	106,843
84,931	4,819	30,340	74,799	4,368	S. Mid.	12,265	25,359	205,998	86,362
60,268	4,830	29,924	54,722	3,601	S. Wales	5,905	27,250	129,012	71,317
109,680	7,945	26,467	51,854	4,441	N. Wales	13,897	40,846	287,529	61,587
164,422	1,469	15,726	44,104	3,006	S. Lancs.	14,277	80,137	498,227	51,300
96,551	6,219	29,196	47,916	3,342	N. East	13,256	45,725	249,430	74,092
66,667	3,913	23,836	39,001	2,819	N. West	8,812	35,252	173,751	30,965
49,383	2,564	16,183	26,140	2,655	Northern	5,487	19,185	117,570	43,797
22,348	4,543	8,609	13,710	537	Ireland N.	137	2,330	45,999	1,560
68,799	5,422	26,949	38,934	1,218	Scot. East	5,412	14,308	158,737	44,655
91,209	7,253	24,438	43,686	1,078	Scot. West	12,360	26,047	227,981	34,969
1,793,252	70,880	371,967	736,838	41,538	Total	198,580	561,582	5,348,082	881,136
1,765,927	70,723	372,339	728,332	41,458	Figures as at at 31st Mar., 1929.	197,156	552,088	5,279,791	883,312

CALL-INDICATOR OPERATION BY MEANS OF AN ORDER-WIRE.

D. A. Christian

(Of Siemens Brothers & Co., Ltd.).

IN a previous issue of the Journal (Vol. 21, Part 2) a method was described for handling calls from manual to automatic exchanges by means of an order-wire, but without the co-operation of a telephonist at the automatic exchange. The use of an order-wire also provides an extremely economical and efficient means of handling calls in the reverse direction, that is, from automatic to manual exchanges. As this method of operation is somewhat similar, while at the same time forming a natural contrast to the previous method it is hoped that a short description may interest readers of the Journal.

In the previous article the subject was introduced by a consideration of the possible methods, from the operating point of view, of handling calls of the class concerned. This was useful since the arrangement described involved a different method of operation from that previously used. In the present case such a consideration is not necessary, since exactly the same method of operation is provided as is already in use in the London Call-Indicator equipments.

The system of order-wire call-indicator working is perhaps most easily understood by drawing an analogy with ordinary manual order-wire working, and this will be done in the following paragraph, which very briefly outlines the method.

The impulses from the subscriber's dial (or from the director in a director area) route the call *via* the ordinary selectors to a link (or trunk) which has associated with it a coder-finder. (See Fig. 1.) The coder-finder searches and extends the call to a free coder. The remainder of the impulses are received by the coder. So far the operation is exactly the same as in the system in use in London. The coder may be considered as an " A " operator, who receives the number required by the calling subscriber. The coder, like the " A " operator, now makes connection with the order-wire and passes the number as a code over the order-wire to the " B " position. The number appears at the " B " position on a lamp display, which is precisely the same from the operator's point of view as those at present in use. The " B " operator selects any free junction cord circuit and after making the usual engaged test inserts the plug in the multiple jack of the required subscriber. For the moment it may be supposed that the number of the junction thus assigned is now transmitted back over the order-wire, as a code, to the coder. The coder, in like manner to an " A " operator, then directs the call by means of appropriate impulses, which it sends to the junction selector, to the outgoing end of the assigned junction. The junction selector in this case would be a two-motion switch stepping under control of the impulses on both vertical and rotary directions.

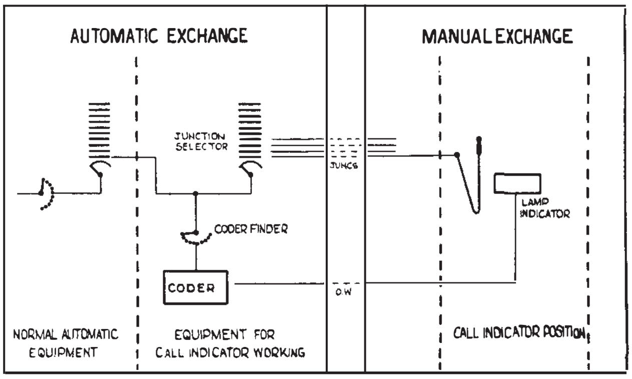


FIG. 1.

Actually it is not necessary to transmit the number of the assigned junction back to the originating exchange and the method, in practice, deviates slightly from manual operation in this respect. In the case of a single order-wire and call-indicator position, the junction selector becomes a 50 point rotary switch and the coder merely receives a signal from the manual end that a junction has been assigned. On receipt of this signal, the coder starts the junction selector searching and since only one junction can be assigned at a time the junction selector will automatically find it.

It will be appreciated that the difference between automatic and manual working which permits the above deviation is the speed of search of the automatic switch, which enables a complete search to be made over the entire group before a succeeding assignment could possibly be given.

So far it has been assumed, for the sake of simplicity, that only one order-wire and one call-indicator position is required to deal with the traffic between the two exchanges concerned, but the application of this method of operation to cases in which several call-indicator positions are required presents no difficulty, and, moreover, the same group of coders may be arranged to handle traffic to call-indicator positions at several different manual exchanges if this is required.

The precise switching arrangements required to meet the conditions of different areas and numbering schemes, of course, vary and each case must be studied separately if maximum efficiency is to be attained; a representative case has, however, been selected for purposes of illustration and the method of operation for this is more fully described below.

The case chosen is that of an automatic exchange which routes calls direct to three different manual exchanges, the junctions to which would be normally accessible from the levels of a second selector in the automatic exchange, say, from levels " 61," " 62 " and " 63 ": the traffic to the first manual exchange requires the use of three call-indicator positions and that to the other two one position each.

An elementary diagram showing arrangements suitable for the above case is shown in Fig. **2.**

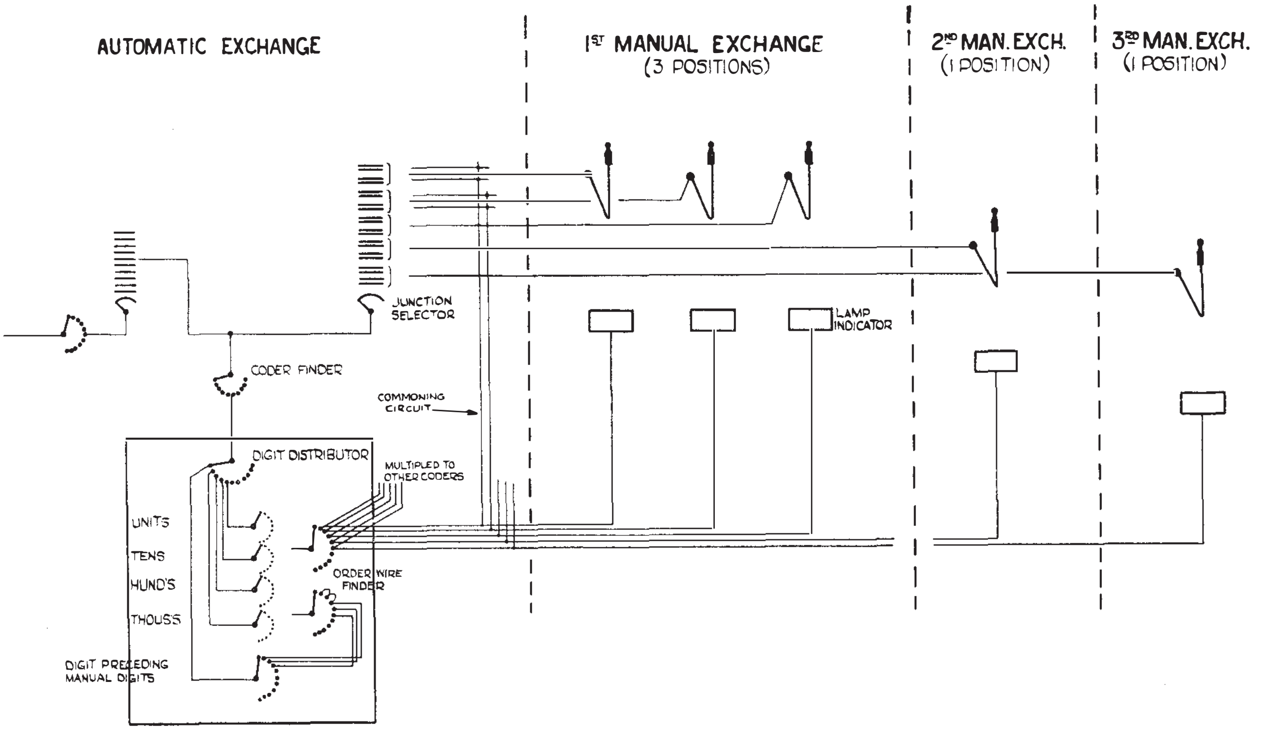


Fig. **2.**

The usual subscribers' line switch and first selector are shown at the left of the diagram. From level " 6 " of the first selector are indicated links going to junction selectors, and with each link is associated a coder finder which gives access to a group of coders. The junction selector is the usual type of 20-link intermediate selector with simultaneous search on both sets of wipers, having in addition incorporated in it the ability to step up and search a succeeding level, if no free outlets are found in the first level searched. This action is the same as that incorporated in the Siemens type P.B.X. Final Selectors for large groups. The arrangement permits a search over 40 outlets in a very short space of time.

The action of a call to, say, the first manual exchange will now be described. The subscriber dials "61" followed by the number required in the manual exchange, which we may assume to be "2345." The first digit (6) raises the first selector to the sixth level, whereupon a free link to a junction selector is obtained: the coder-finder searches and obtains a free coder. The second digit (1) is now received on the single-motion switch shown at the bottom in the diagram of the coder. The digit distributor steps and the manual digits (2345) are received on the thousands, hundreds, tens and units switches as indicated. When the units digit has been received, the order-wire finder switch in the coder searches for a free order-wire, but in doing so it is constrained by the position of the switch which has received the digit preceding the manual digits to test only on those order-wires leading to the manual exchange required. We may assume that the first order-wire to this exchange is engaged and that the order-wire finder has made connection with the second order-wire. Codes corresponding to the manual digits are now transmitted practically instantaneously over the order-wire and the number (2345) appears on the lamp indicator at the manual position. The operator now selects any free junction plug on her position and after making the usual engaged test inserts it into the multiple jack required. This action sends a signal back over the junction selected, which finds its way to the coder, *via* the commoning circuit indicated in Fig. **2**, and which indicates to the coder that a junction has been assigned. The coder on receipt of this signal sends a train of impulses, the number of which is determined by the position of the order-wire finder switch, which raise the junction selector to level 7, whereupon search over level 7 (and if necessary over level 8) enables the assigned junction to be found and the through connection is completed. The coder is now released and is ready for further use.

The levels of the junction selector from which the various junction groups are taken have no numerical association with the digits dialled to obtain the particular exchange. The impulses transmitted by the coder to raise the junction selector to the required level are arranged as required by means of local strapping in the coder.

Different requirements with respect to the size and number of manual exchanges served will chiefly influence the arrangement for routing the call to the particular junction group. The switching arrangements adopted for this purpose are, however, quite flexible and may consist of any combination of switches desired; for instance, outgoing preselectors may be incorporated or the junction selectors may consist of two ranks of selectors, as circumstances dictate: the coder impulsing circuits being, of course, arranged to suit.

In the above description of the action several features have been omitted for the sake of clarity and to these reference may now be made.

The calls are handled in strict succession in the order of their arrival; by arrival being understood the reception of the units digit in the coder. This is accomplished by providing a group of marker switches for each manual exchange served, which associate themselves in turn with the coders immediately the last train of impulses has been received. Immediately a coder receives its full complement of digits, it thus, in effect, takes its place in a queue for the particular exchange required. The coders then take their turn in being served by the group of order-wires serving the wanted exchange, each order-wire as it becomes free takes the next coder waiting for its exchange. The calls are thus distributed over the positions in the manual exchange which serve each automatic exchange. Arrangements can be provided which show in the manual exchange how many calls are waiting for attention at the particular automatic exchange.

The method of giving the busy signal to the calling subscriber when the called line is found engaged is particularly simple. On finding the called number engaged, the operator momentarily depresses a key, which is common to the position. The depression of this key passes the same signal to the waiting coder as does the action of inserting one of the junction plugs into the multiple; the signal in this case passing back over the order-wire. The coder is thus informed that a junction has been assigned when, in fact, no assignment has been made. The call is consequently directed to a selector level in which it can find no outlet in a condition to be picked up, and the junction selector therefore reaches the busy contact at the end of the level and busy signal is given to the calling line. Since the various circuits act in their normal manner during the above operation, no extra complication is involved in providing the facility. It may also be noted that a junction is not held during the period in which the busy signal is applied.

All the usual facilities appertaining to the junction or cord circuits, such as supervision, automatic ringing or flashing recall can, of course, be provided as required. The junction circuit in fact differs only from an ordinary manual order-wire junction circuit in the provision of means to pass back the assignment signal to the outgoing end when the plug is inserted in a multiple jack.

Calls requiring assistance are simply dealt with by plugging the junction through to a service line terminating at a position where the necessary assistance can be given. During slack periods, the operator can herself speak to the calling subscriber by plugging into a jack associated with her telephone circuit and, after obtaining the necessary information, the junction plug can be withdrawn from this jack and inserted in the required multiple jack.

An interesting feature is the simplicity with which a breakdown service can be provided should a fault occur on the order-wire. The order-wire is dispensed with entirely and the operator pre-assigns a junction by inserting any junction plug in the jack associated with her telephone. The action of the various circuits now proceeds exactly as already described up to the point where the coder sends the code signal to the manual exchange. Since the order-wire is disconnected, the signal is, of course, ineffective, but due to a junction being already assigned the coder now receives the usual signal to direct the call to the junction group; which it does. The call now finds the preassigned junction and since this junction is connected through to the operator's telephone circuit, the operator can ask for the number required and then transfer the junction plug to the multiple. A click signal is given in the operator's telephone when a call thus arrives.

In this description, which deals only with the general arrangements involved in Order-Wire Call-Indicator Operation, no reference to the circuit arrangements has been made and no circuit diagrams illustrated; these are in fact quite incidental to the general scheme. They involve no point of particular interest in circuit design and would be of use only to a minority of readers of the Journal. The amount of apparatus required, particularly at the manual exchange is, however, an important feature of this method of call-indicator working and details of that required for the arrangement shown in Fig. **2** are given in the following list :—

	Relays.	Single Motion Switches.	Two Motion Switches.
Automatic Exchange—			
Coder Finder ...	5	2	—
Coder	10	8	—
Junction Selector...	3	—	1
Outgoing Junction Circuit	4	—	—
Outgoing Order-wire Circuit ...	4	—	—
Manual Exchange—			
Position Circuits ...	32	—	—
Junction Circuit ...	7 + one retard coil	—	—

In conclusion it may be useful to summarise the most important and interesting features of the scheme.

(*a*) No automatic apparatus is required at the manual exchange.

(*b*) Apart from the junction circuits themselves, only thirty-two relays are required at the manual end for each call-indicator position.

(*c*) The junction circuits are quite simple, since in addition to the ordinary supervisory signals only the assignment signal is passed over them.

(*d*) The code signals are simple because they are confined to the order-wire, and it is therefore economically possible to provide four conductors to transmit them.

(*e*) Coders may be arranged in a common group serving several manual exchanges.

(*f*) Calls are distributed to the call-indicator positions, serving the particular automatic exchange, in rotation.

(*g*) It is not possible to distribute calls from more than one automatic exchange over a common group of call - indicator positions, but this is not possible in manual-to-manual operation and although advantageous, should not, except in special circumstances, be essential.

(*h*) Busy signal is given from the automatic exchange without holding a junction engaged.

(*i*) Reasonable breakdown operation can be given even if the order-wire is entirely disconnected.

The writer is indebted to Messrs. Siemens Brothers & Co., Ltd., in whose laboratories this scheme was developed, for permission to publish the above description.

[*The system described in the foregoing article is not used by the British P.O. Department.—Eds., P.O.E.E. Journal.*]

A NEW C.B. MICROTELEPHONE.

A. J. Aldridge, E. J. Barnes, E. Foulger.

INTRODUCTION.—In August, 1927, the Research Section was asked by the Engineer-in-Chief to design a microtelephone which would be equal to any instrument of that type then available, and which would not infringe any existing patents.

Extensive tests of microtelephones from all sources had been carried on for many years, but the results were generally far inferior to those obtained with the fixed solid back transmitter and Bell receiver of the P.O. standard pedestal telephone.

General features of the proposed instrument. The requirements which it was desired the instrument should meet were:—

Electric and Acoustic.—

(1) Sending efficiency should not be more than 1.4 d.b. worse than P.O. basic standard.

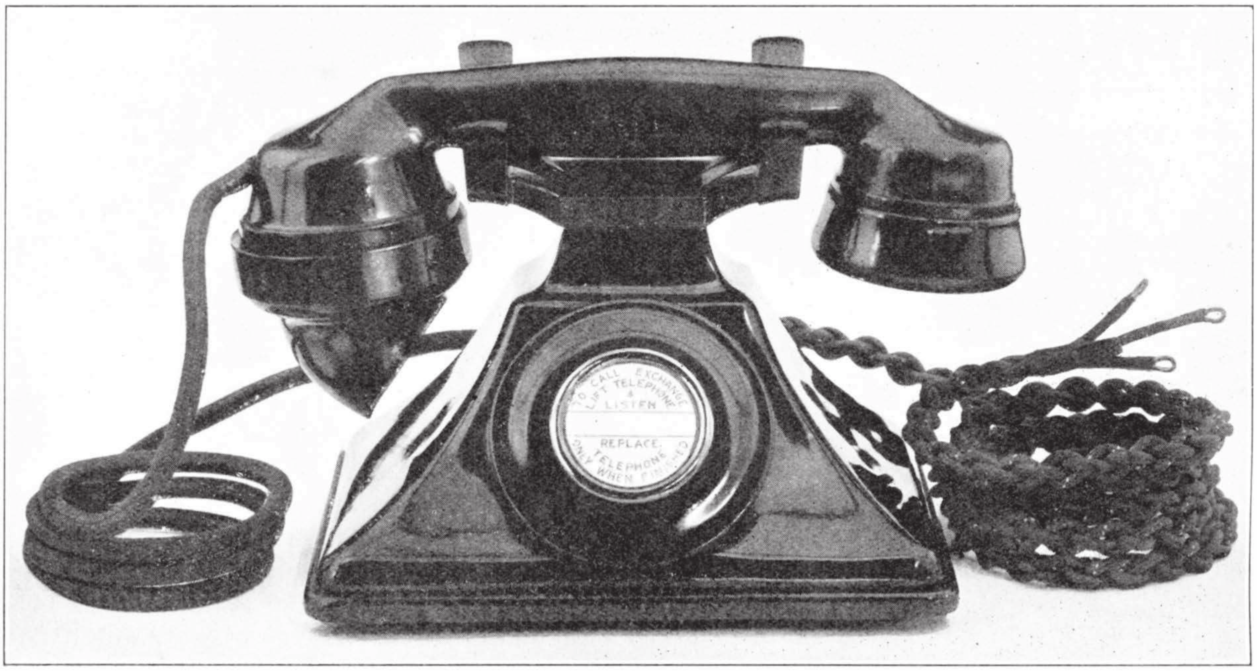

TO CALL EXCHANGE LIFT TELEPHONE & LISTEN
REPLACE TELEPHONE ONLY WHEN FINISHED

Fig. 1.—The new C.B. Microtelephone.

(2) Receiving efficiency should not be more than 1 d.b. worse than Department's standard.

(3) Articulation should be 10%, or more, better than standard.

(4) Frying and packing should not be worse than on the No. 1 C.B. Transmitter.

(5) The instrument should be capable of use without serious change in efficiency when used in any practicable position.

(6) The instrument should not " howl " on a short local line.

These desiderata are rather severe, but it was considered advisable to work to them if possible.

Several patterns of headgear type receivers giving good transmission efficiency were known and no difficulty was expected in adapting any of these for this purpose. Attention was therefore mainly concentrated upon the transmitter and the following mechanical points were kept in mind:—

(1) Transmitter and Receiver should be of " inset " type for ease of replacement.

(2) The granule chamber should preferably be self-contained on the lines of the No. 1 transmitters, as this has been found in the past to be a good design.

(3) The mouthpiece should be hygienic and easily cleaned.

(4) The instrument should be robust, of pleasing appearance and not easily interfered with by the subscriber.

Transmitter Design.

A large number of model transmitters were made up, mainly by using parts of the No. 1 C.B. transmitter. The points which were chiefly kept in mind were means to enable the transmitter to work in any position, the reduction in the sharp resonance of the No. 1 Transmitter, and the improvement in efficiency by reduction of the weight of the moving parts.

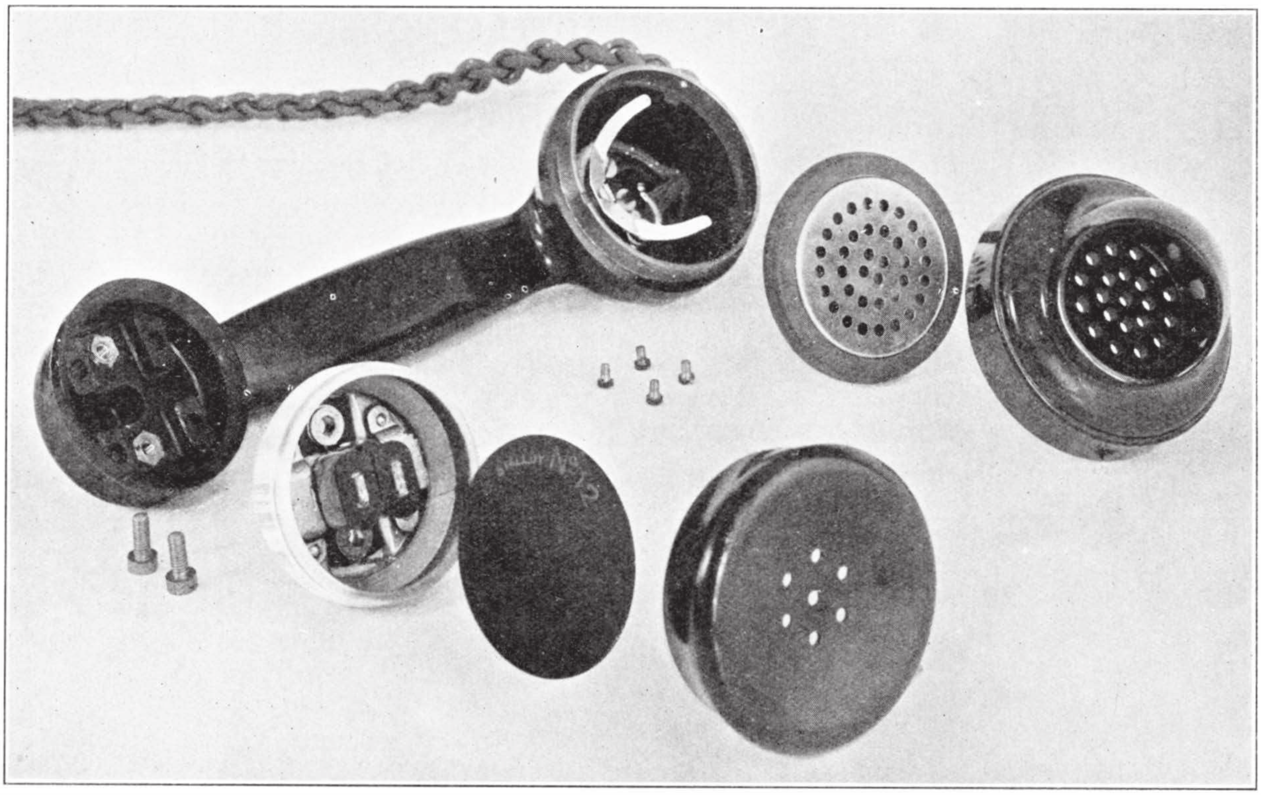


FIG. 2.—THE HAND-SET ASSEMBLY.

The most satisfactory model consisted of a granule chamber made up in cylindrical form, the end away from the diaphragm being closed with a mica diaphragm and electrode, identical with that in the No. 1 transmitter except that the excess brass present was very considerably cut down. This moveable electrode was connected with the diaphragm by means of an insulated bolt passing through the granule chamber. The other electrode was in the form of a gold-plated ring fixed about half-way down the chamber.

Satisfactory performance was obtained with transmitters of this type as regards maintenance of efficiency when used away from the vertical, but it was soon found that when the diaphragm was reduced to a size suitable for use in a microtelephone the sending efficiency fell away seriously. This was remedied by the use of a coned diaphragm of thin aluminium with an annulus of thin surgical silk to reduce the stiffness. This diaphragm was later replaced by one consisting of two opposed cones, between which the annulus was clamped. This produced a more rigid piston and also eliminates the difficulty of attaching the annulus to the cone. The silk annulus was also later replaced with one of thin aluminium foil. The result is a stiff, piston type diaphragm, with a very flexible edge; the weight of the whole moving system is under two grammes as against 7.8 grammes for the No. 1 type transmitter.

Shape of Handle. The first handles made were of triangular section with rounded edges, the handle itself sweeping into a more or less hemispherical boss carrying the transmitter, and into a similar but smaller boss carrying the receiver. After considerable discussion, and the examination of various different experimental models, a shape was finally adopted which is very similar to that of the A.T. & T. Co's. instrument.

The length of the handle was based upon fresh measurements of a large number of heads, and is actually 5″ between the centre of the earpiece and the nearest point of the transmitter case. The inside of the mouthpiece is a nearly cylindrical tube with a bore of about $1\frac{3}{8}''$. The transmitter inset itself is provided with a perforated metal guard, the holes in which are out of line with the holes in the grid at the base of the mouthpiece, so that there is no possibility of objects being pushed on to the diaphragm. The plane of the opening of the mouthpiece is at an angle of about 45° with the line of the handle, so that a shorter handle is possible than would otherwise be the case without causing the lips of a long-headed user to touch the instrument.

Complete Test of 5 C.B. Microtelephones. Six complete handles (somewhat different in shape from the final models) were made up in ebonite and fitted with transmitters and receivers. The receivers were of the Sterling Telephone 1A pattern and no special steps were taken at this time to ensure that they were the best obtainable. Five instruments were submitted to test, the other being kept apart for demonstration if required.

The following is a summary of the results obtained, each transmiter being tested in the handle by 20 speakers to obtain a reliable average. All tests were made on Standard C.B. 300-ohm local :—

Volume efficiency, head in normal position.	1.5 d.b. Worse than Standard.
Range between instruments	0.3 d.b. to 2.7 d.b. Worse than Standard.
Receiving efficiency	2.5 d.b. Worse than Standard.
Range	0.2 d.b. to 6.2 d.b. Worse than Standard.
Articulation	6% Better than Standard.
Range	8% Worse — 22% Better than Standard.
Naturalness (Ease of recognising a voice)	Errors reduced to 75% in comparison with No. 1 C.B.
Resistance	61 ohms.
Range	54-77 ohms.
Frying	Passes specification for No. 1 transmitter at any angle up to 45°.

The "naturalness" test was made because it was felt the articulation figures did not fairly represent the improvement. It is well known that a receiver, for example, when used as a transmitter, is very articulate but the tone is unnatural, being thin and reedy. The "naturalness" test was made by twelve observers, well-known to one another, each reading to each of the others a short passage. The observer was required to name the reader. It was found that on the average with the No. 1 transmitter 33% mistakes were made, whereas with the new transmitter 25% mistakes were made.

A microtelephone fitted with a good transmitter and a good receiver showed no tendency to "howl" on a 35-ohm local.

It will be seen that these transmitters are superior to the average supplies of No. 1 C.B. transmitters (last 3 sample batches were 2.4 d.b. worse than Standard) in both volume and articulation.

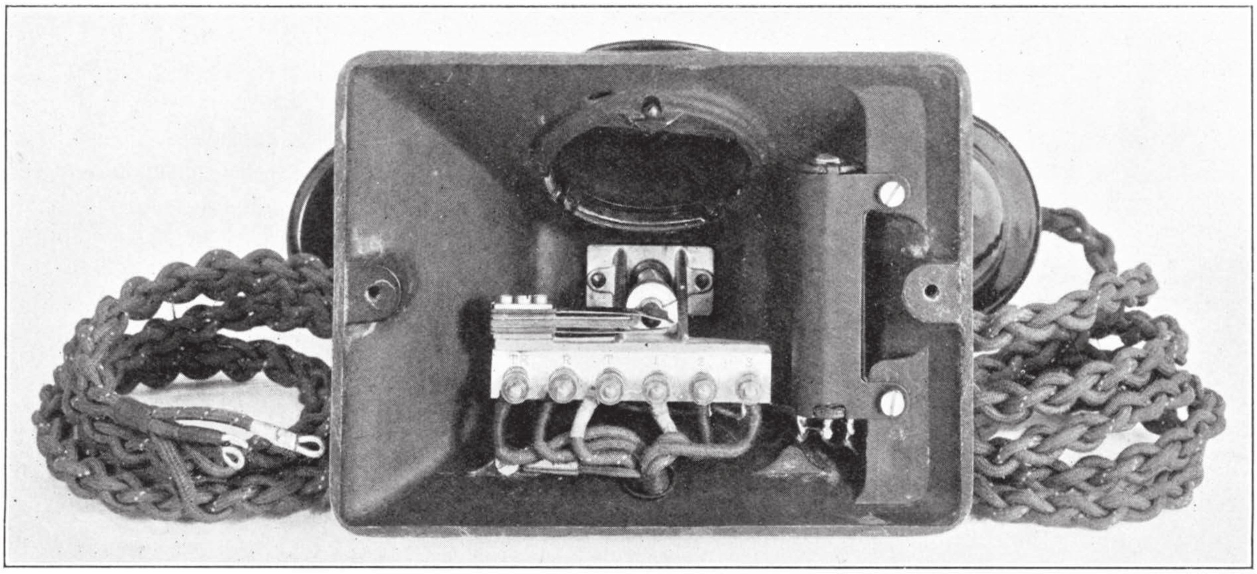


FIG. 3.—VIEW UNDER BASE OF CRADLE.

Life Test. Four of the transmitters were subjected to the usual life test of 30,000 operations and the following table gives the complete results after this:—

EFFICIENCY TESTS AFTER 30,000 OPERATIONS.

Trans-mitter No.	Head Vertical.			Head at 45°			Head Horizontal.		
	Effcy. d.b.	Resis.	Articu-lation	Effcy. d.b.	Resis.	Articu-lation	Effcy. d.b.	Resis.	Articu-lation
	11 Observers	Ohms		11 Observers	Ohms		3* Observers	Ohms	
B	0.4W	72	4% B	0.8B	104	8% B	1.9B	140	Not tested
C	0.3B	96	10% B	0.7B	113	7% B	0	159	16% B
D	0.6W	78	1% B	0.4B	117	10% B	3.6W	157	3% B
E	1.4W	71	6% B	1.0W	95	3% B	0.4B	184	4% B
Mean	*0.5W*	*79*	*5% B*	*0.2B*	*107*	*7% B*	*0.3W*	*160*	*8% B*

* *The results obtained with the three observers have been corrected to allow for the fact that they were not average.*

The transmitters had thus somewhat improved in efficiency but the resistance had risen. This rise may be the cause of the improved efficiency.

Efficiency and articulation were well maintained, *at any rate up to the 45° position.* Tests were made in the 90° position as a matter of interest, but the position is only reached in practice with very considerable discomfort.

The resistance is high, particularly in positions away from the vertical position, but this latter is not of great importance in a microtelephone for the reason that the transmitter is almost certain to be put into a vertical position before being put into the " use " position. This would cause the supervisory signals to be operated and these will then remain operated for any position of the transmitter. Steps were, however, taken to reduce the resistance.

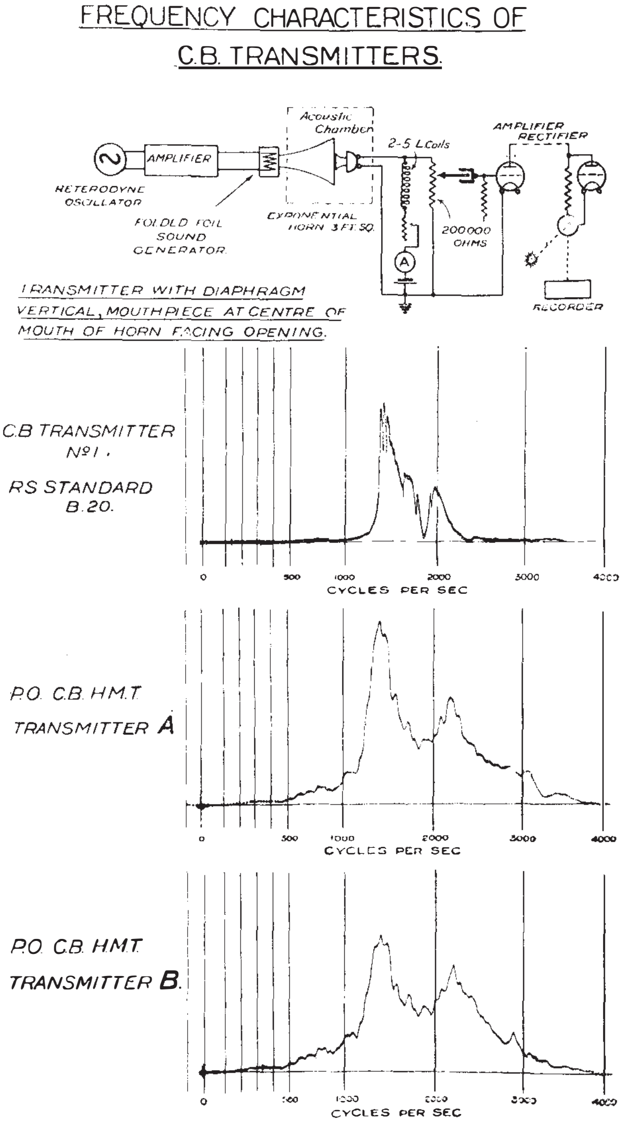


Fig. 4.

Mechanical Test. Three transmitters were taken from the handles and mounted in a wooden frame which could be raised one quarter of an inch and then dropped on to a block of wood.

The frame was dropped 50,000 times, and volume and resistance tests were then again made.

An average reduction in efficiency of 1.4 d.b. was obtained.

Frequency Characteristics. Frequency characteristics of two of the transmitters with a representative No. 1 C.B. transmitter for comparison are given in an accompanying figure. It will be seen that the characteristic is a considerable improvement over that of the No. 1 Transmitter.

Reproducibility. It was found that if proper precautions were taken in manufacture and assembly, different transmitters gave very similar efficiencies, and a transmitter could be dis-assembled and re-assembled without appreciable change in efficiency.

Manufacturing Development. These results were considered so satisfactory that steps were taken, under the usual Departmental procedure, to obtain Provisional Protection. The Department then approached Messrs. Siemens Bros., with a view to their taking up the provision of commercial models, as it had been found that that Company had been developing a microtelephone and had reached about the same position as the Department. Tests of Messrs. Siemens transmitter, which was of quite different design, gave results almost identical in all respects with those obtained with the Department's transmitters. It was therefore decided to make certain small mechanical modifications with a view to the use of either transmitter in a common handle. Messrs. Siemens Bros. were given an order for a considerable number of each pattern with a view to both types being given a commercial trial.

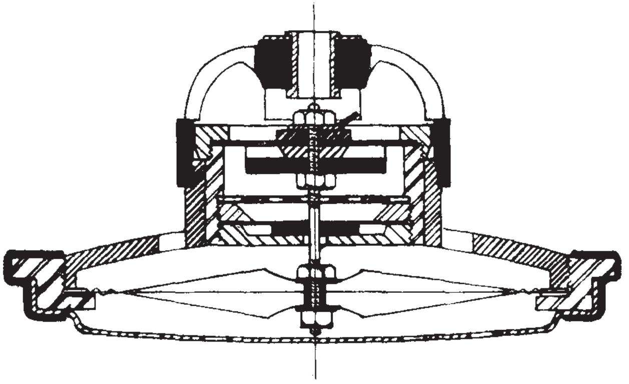


Fig. 5.—P.O. Type Transmitter.

Particulars are given in the accompanying drawings and photographs of the complete instrument, and of both the P.O. and Siemens pattern transmitter, either of which can be used in the one handle.

A short description of each transmitter is given.

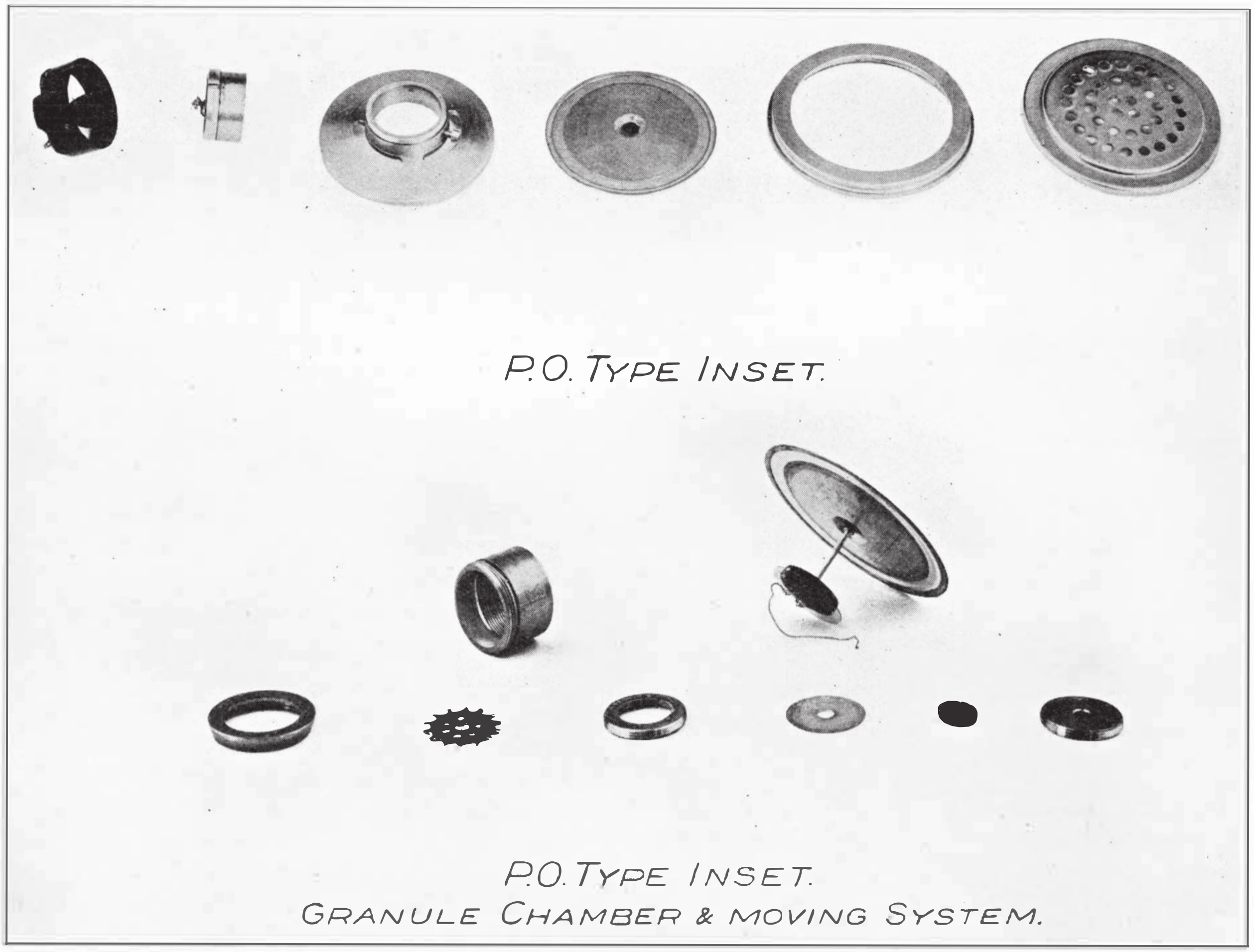


Fig. 6.

P.O. Transmitter. The diaphragm receiving the sound is a double cone aluminium piston, the two cones being riveted together with a perforated ebonite rivet, and clamping between them an annulus of aluminium foil. The outer edge of this is strengthened by two thin brass rings cemented to it. These form the clamping surface. Through the ebonite centre rivet a small bolt is passed to which the piston is bolted. The bolt passes (insulated) through the granule chamber and carries the moveable carbon electrode. This is polished and is of the same size as the front electrode of the No. 1 Transmitter but it has no brass backing. Clamped to it, as shown, is the mica diaphragm which closes the side of the granule chamber remote from the piston diaphragm. The other electrode is an annular ring of brass, gold-plated, and perforated with a number of holes. These holes allow of free granule movement and cause a lower resistance than occurs with a solid electrode. They also render more easy the filling in of the granules. It will be seen that both electrodes are almost completely embedded in granules and that as the transmitter is turned over on its back more and more of the granules are carried by the moveable electrode. This ensures the maintenance of good working in any position.

Siemens Transmitters (*Patent No.* 308630). The diaphragm receiving the sound is a single corrugated aluminium cone. Attached to the centre is a small aluminium cylinder, the other end of which carries one electrode (carbon). This cylinder projects into the granule chamber as shewn. The other electrode, also of carbon, is mounted at the base of the granule chamber, which of such a size that the two electrodes are correctly spaced apart at about the centre of the chamber. The granules are prevented from escaping by annuli of silk clamped in the granule chamber and forming a sliding fit on the cylinder attached to the diaphragm. It will be seen that in this pattern also both electrodes are almost completely embedied in granules in any position of the transmitter.

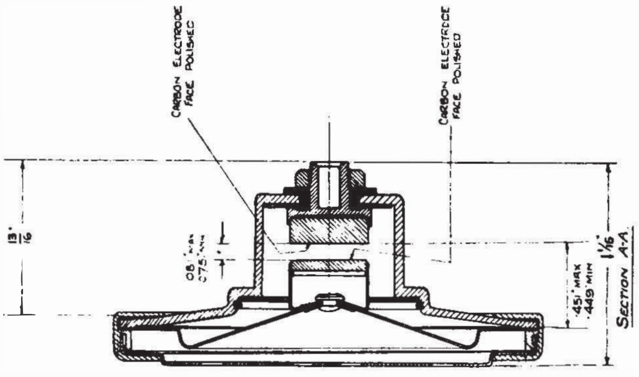

CARBON ELECTRODE FACE POLISHED
CARBON ELECTRODE FACE POLISHED
13"/16
·08" MAX
·075" MIN
·451" MAX
·449" MIN
1 1/16
SECTION A-A

Fig. 7.—Siemens Type Transmitter.

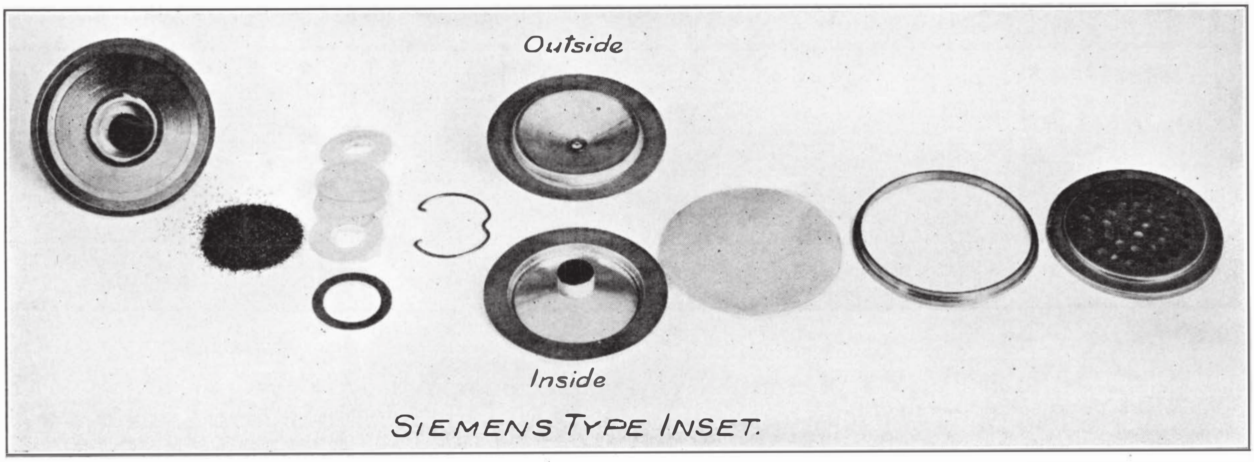


Fig. 8.

Both transmitters are made up as insets, contact being made in the same way in each, viz.: by plug and socket for one connection and springs on the case in the other.

Receivers. The only special points about the receivers are the provision of a substantial aluminium case, giving a good seating for the diaphragm, and the use of a straight cobalt steel magnet. The receiver is attached to the handle by two clamping screws which also form the terminal connections.

Side Tone and Extraneous Noise. The high efficiency of these instruments produces very considerable side tone, and also renders any noise in the room very distressing. It was agreed that some form of anti-side-tone circuit was essential, and the most effective arrangement was considered to be one which had been brought out by Messrs. Siemens. This consists in the addition of a small subsidiary, two-winding induction coil, one winding being connected across the receiver terminals and the other across the transmitter, and so connected that the subsidiary output from the transmitter into the receiver is in opposition to the normal transmitter output into the receiver.

The inherent effect of this coil is to reduce the sending efficiency by about 2 d.b. but this is almost exactly compensated for by the fact that in practice when the side tone is reduced the voice is somewhat raised in volume. Reception efficiency is reduced by about 0.5 d.b. The side tone and extraneous noise are reduced by from 7 to 10 d.b. The subsidiary coil is mounted in the base of the cradle. The instrument is connected to the Bell Set No. 1 by the usual three conductor cord and can be used interchangeably with Telephones Nos. 2, 124, etc.

Performance. A number of difficulties have been experienced in testing these instruments. These are due:—

(1) To the large differences obtained in efficiency with different speakers due to:
    (*a*) Size of head.
    (*b*) Shape of head.
    (*c*) Character of voice.
(2) The effect of the side tone.
(3) The effect of the presence of the instrument on the head in its relation to the picking up of the sound vibrations, other than directly on the diaphragm.

In normal transmission testing the receiver at the sending end is not held to the head, but in this case it must play some part. The use of a guard to fix the distance of the speaker is inadmissable, partly, because it eliminates the effect of any communication of sound down or from the handle and, partly, because a man with a large head will produce much side tone and will therefore tend to reduce his voice more than will a man who produces less side tone.

The method finally adopted to determine the efficiency is to use 20 speakers, each man holding the microtelephone to the head in the normal way. The anti-side-tone coil is in use, and the microtelephone receiver also alive. On the standard circuit a transmitter and receiver, as nearly as possible each equal to standard, are used, and the receiver held on the ear when speaking. Several microtelephones were thus standardised against the usual standards and used subsequently as substandards to calibrate other microtelephones. For this calibration, substandard and test microtelephones were each fitted with wire guards at approximately the average speaking distance and the guards spoken to close up as to a No. 1 C.B. transmitter.

Four P.O. instruments were selected as substandards, the sending allowance of the complete instrument, obtained as outlined, being in each case 0, in terms of the Department's standard.

A number of instruments of each pattern (constructed by Messrs. Siemens Bros.) have now been tested and the following Table gives the results.

All results are in terms of the Department's Standard transmitter or receiver.

Trans.	No. tested	Allowance in d.b.		Resistance * ohms	
		Mean	Range	Mean	Range
P.O.	25	1.5 Better	0.2 Better—3.5 Better	47	39—55
Siemens	45	1.5 Better	0.1 Worse—3.4 Better	45	35—60
Receivers	70	0.9 Worse	1.0 Better—3.7 Worse		

* These figures include the anti-side-tone coil.

The articulation of both types of transmitter is distinctly superior to that of the No. 1 C.B. transmitter, but it is difficult to give a quantitative statement of the amount. Results have been obtained with these samples varying from 4% Better to 45% Better. The figure depends upon the observers making the test, upon the conditions of the test and upon the circuit conditions. For example, a direct test between a No. 1 C.B. transmitter and the microtelephone on the working circuit does not necessarily produce the same relative articulation efficiency as is obtained by a test of each instrument against a distortionless circuit. The two patterns of transmitter are found to give practically identical results, and probably an average figure of about 15% better than standard is about right.

All the transmitters are satisfactory as regards frying when the microtelephone is held on the head, the latter being vertical. About 20% exceed the allowable amount when the head is held at 45°, and most are unsatisfactory when the head is held with the line through the ears vertical. This position is only reached with very considerable discomfort.

Tests have also been made of the possibility of sparking occuring in the transmitter whilst being lifted from or replaced on the switch-hook.

With the Siemens type of transmitter it was found impossible to produce a disconnection in the transmitter whilst the switch-hook contacts were closed.

With the P.O. type a disconnection could only be produced when the microtelephone was replaced on the cradle in a very violent manner. With neither type did the resistance rise to any very high values when the microtelephone was handled normally.

It should be mentioned that since the preliminary samples have been obtained, various minor modifications have been made in the P.O. inset. These should result in an even better transmitter.

THE MECHANICAL TESTING OF TRANSMITTER AND RECEIVER EFFICIENCIES.

A. Hudson, B.Sc., A.C.G.I.F.C., A.M.I.E.E.

INTRODUCTION. — The present method used by the British Post Office of testing transmitters for volume efficiency, whether for factory acceptance tests or laboratory precision tests, involves the co-operation of at least two observers. One observer talks in some standardised manner into, first, the test transmitter, and then into a standardised transmitter, the necessary circuit alterations being made by means of suitable relays. The other observer listens to the output from the two transmitters in turn and either adjudges which is the better of the two, as in factory acceptance tests, or carries out an elaborate balancing test with a third observer with the object of assessing the exact difference between the two transmitters, and hence determining the efficiency of the transmitter under test in terms of the Department's standard transmitter.

The object of the mechanical test is to replace the talker by an electro - acoustic convertor actuated by some form of oscillator, and the listener by some form of value voltmeter so that the whole test may be made by one man in a fraction of the time required by the laborious laboratory tests and with the same accuracy.

At first sight it would appear that such a method should be capable of giving very great accuracy, as the whole of the elements of the test are subject to exact calibration and specification. Such, however, is not the case, owing to the fact that the results to be of value must give, within fairly narrow limits, the same result that would be obtained by a laboratory speech test.

The Research Section has developed a mechanical test which has achieved a considerable amount of success in this connection, by ensuring that the speech test should be copied in almost every particular, if the same result is to be obtained by the mechanical test.

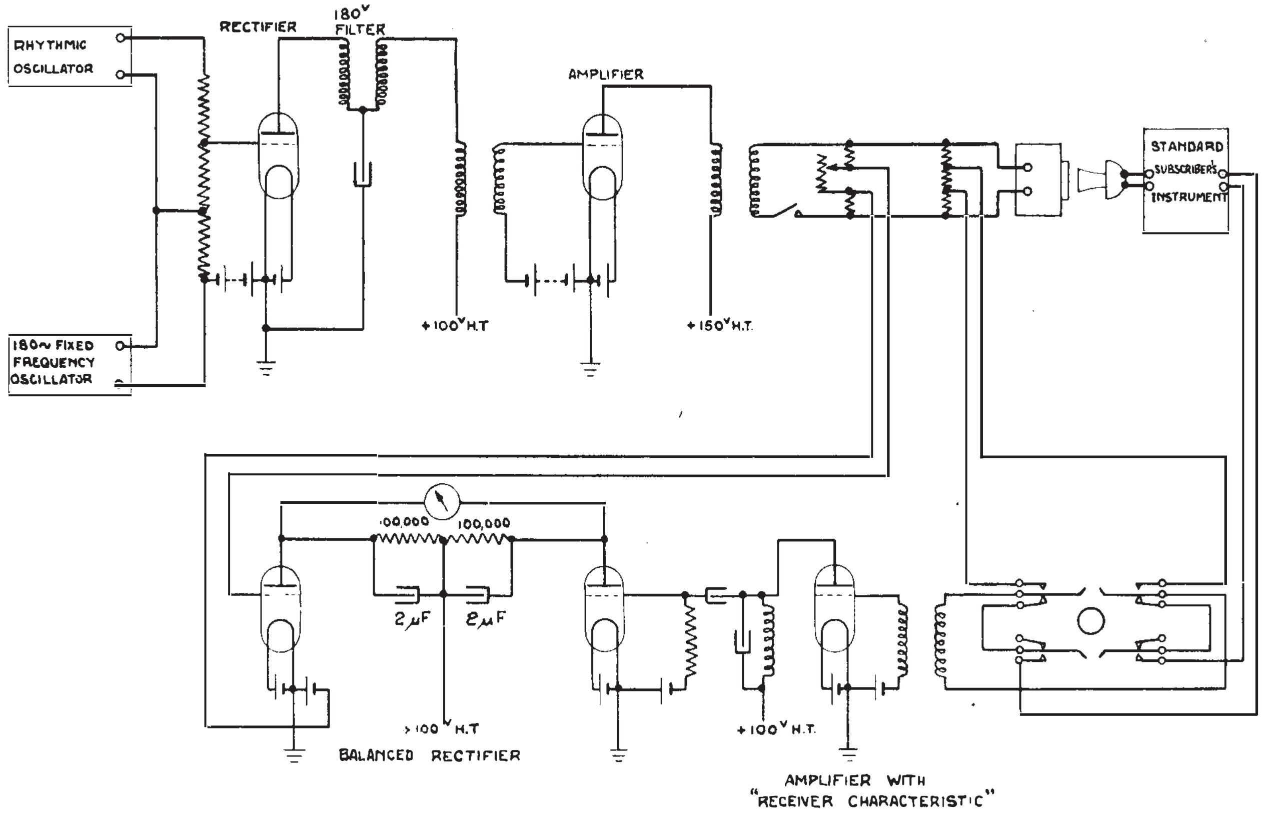
Oscillator.—The voice of the talker is replaced by a moving coil loud speaker of special construction. This is actuated by a modulated rhythmic oscillator. The rhythmic oscillator ranges from 100 to 1,600 cycles per second at 250 rhythms per minute. This rhythmic frequency is then modulated by a fixed frequency of 180 cycles per second. The 180 cycles per second is filtered at a later stage, so that finally three frequencies, apart from harmonics, are present in the resultant noise at any one moment. The result is a sound which, apart from transients, can be said to possess the same essentials as speech. A considerable number of tests shows that this type of sound has a great superiority over a rhythmic oscillator producing a pure note.

Voltmeter. — The listener is replaced by a special valve voltmeter or amplifier rectifier set, which is connected to the output side of the repeating coil on the present standard transmitter testing circuit.

The amplifier has incorporated in it a tuned circuit, so that its frequency voltage characteristic follows the same curve as a receiver on an ear; the rectifier has a " straight line " voltage output characteristic.

The standard method of testing a transmitter is to compare it with another, a standardized transmitter. The same principle, namely, that of comparison with some form of standard, has been kept in the rectifier circuit, as may be seen from the schematic diagram.

The output from a transmitter, after amplification, is applied to an anode bend rectifier. At the same time a given proportion of the A.C. voltage applied to the loud speaker is taken to another anode bend rectifier. The anode circuits are each fed with plate current through 100,000 ohms shunted by 2 μF. condensers. The two anodes are connected to opposite terminals of the measuring instrument, hence the instrument will only read the difference in potential of the two anodes. If the two A.C. inputs are equal, no deflection is obtained. If, on the other hand, they differ, a deflection is obtained in one direction or the other, the difference being readily expressed in S.M. by means of a special scale on the instrument.



Routine Testing Set for Transmitters and Receivers.
Schematic Diagram showing Balanced Rectifiers.

The current taken from the loud speaker input circuit is arranged to be of such a value that if a Department's standard transmitter be placed under test, the resulting deflection is nil. Then, if the transmitter under test is either better or worse than Department's standard the instrument needle will read accordingly, the exact efficiency being read off directly.

Calibration.—In a set designed for the use of the Test Section, the Department's standard transmitter is replaced by a potentiometer in parallel with the loud speaker; a key is provided so that this voltage may be applied to the amplifier rectifier in place of the output from the test transmitter. The balancing voltage is made adjustable, so that zero deflections may be given by a test transmitter of any required efficiency, better or worse, than Department's standard transmitter. This facility much increases the ease in making acceptance tests, since with a centre zero instrument all corrections for acceptance figures, etc., can be made once for all. Under these conditions the only apparatus that is not given a routine check is the loud speaker.

The only simple method of checking the loud speaker is to place a standard transmitter in the test position (two or more being used) and to compare the figure obtained with the figure given by the potentiometer check. If there be any discrepancy, it may be adjusted by altering the distance between the transmitter mouthpiece and the loud speaker.

It is hoped that a new arrangement of the loud speaker diaphragm now under design will be sufficiently stable to need only occasional calibration by acoustical methods. By this means the method will eventually become independent of the Department's standard transmitter, its place being taken by the voltage to acoustical pressure ratio determined from tests of standard transmitters.

Results.—The results obtained by this method show a close approximation to those obtained by speech testing when both the No. 1 C.B. transmitters or the new C.B. microtelephones are tested. The errors, under the test conditions, are of the same order as the actual calculated speech test errors.

A recent batch of transmitters, 39 in number, gave an average difference between speech and mechanical tests of 0.65 S.M. with a maximum of 1.9 S.M. Another batch of 136 transmitters gave an average difference of 0.98 S.M. with a maximum of 2.9 S.M. In a large number of batches of transmitters, making 301 in all, an average of 1.0 S.M. is obtained with a maximum of 3.5 S.M. These results should be compared with the best obtained from a method employing a simple rhythmic oscillator and ordinary type valve voltmeter, which under the best conditions gave an average difference of 2.5 S.M. with a maximum of 6.5 S.M.

Application.—The most immediate field of application for a test of the nature described above is in testing bulk supplies of transmitters. The method in use at present leaves much to be desired from the point of view of both reliability, cost of performing the test and strain on the operators.

The new method gives the efficiency of the transmitter within 1 S.M. on the average, so that it will be possible readily to select transmitters for zoning purposes. One operator only is required to use the set, and as no adjustments are necessary once the set is in going order, no large amount of technical skill is required. The test occupies approximately 24 seconds, including a test of transmitter resistance. Assuming that good arrangements are made for feeding the set it may be possible to attain speeds of testing of the order of two transmitters a minute. It should be remembered that this speed may be kept up for long periods at a time, as the efficiencies obtained will not suffer in accuracy due to fatigue on the part of an operator; so that it will be possible to test 600 or 700 transmitters per day per set as against the present figure of 250.

Receiver Testing.—The method described here can also be used for testing receivers. A dummy ear with a mouthpiece attachment, such as is used in conducting *in situ* tests on subscribers' instruments, is placed on the receiver under test and then applied to the loud speaker in exactly the same manner as would be the transmitter. The rest of the test then proceeds in exactly the same manner, additional amplification being provided so that the same standard voltage that is used for transmitters may be used for receivers.

The accuracy of the test is approximately the same as for transmitter testing, when a pure tone rhythmic frequency is used. Further tests are being made with the modulated oscillator, and the indication is that greater accuracy still may be expected.

Testing C.B. Microtelephones. — The possibility of testing both the transmitter and the receiver on the one set quickly, and with no circuit changes beyond throwing a key allied with the great difficulty of making satisfactory speech tests, make this type of testing set of great advantage in the testing of C.B. microtelephones and it is probable that one will actually be used in making the acceptance tests of the new C.B. microtelephones.

THE ANGLO-IRISH AND MANX (1929) SUBMARINE TELEPHONE CABLES.

W. T. Palmer, B.Sc., Wh.Ex., A.M.I.E.E.

EARLY in June of this year the Isle of Man was placed in telephonic communication with England, and thus with the outside world, by means of a lead-covered, continuously-loaded, paper-core submarine cable of length 58.69 nauts. This submarine cable was laid between Port Grenaugh (Isle of Man) and Norbreck (near Blackpool) by the C.S. "Faraday" of Messrs. Siemens Bros. & Co., Ltd., Woolwich, by whom the cable was manufactured. It is linked with Port Erin Repeater Station from Port Grenaugh by 7.81 nauts. of land cable of similar construction to the submarine cable, except that the latter has two lead sheaths and is armoured with galvanised iron wires whilst the former has only one lead sheath. (See Fig. 1). The sea cable is also linked from Norbreck to Blackpool Repeater Station by a length of 2.60 nauts. of similar land cable, the joints at Norbreck and at Port Grenaugh being "switched" for the purpose of minimizing the cross-talk. The total length of the paper-core cable from Blackpool to Port Erin is thus 69.1 nauts. The total diameter of the land cable is 1.12 inches and its weight is 5.5 tons per naut., while the total diameter of the submarine cable is 2.3 inches and its weight is 21.5 tons per naut.

There are four quads (16 conductors) and a single central stranded conductor, each conductor being wound with special iron wire, to increase its inductance, and insulated with three wrappings of paper. The centre wire and earth-return circuit is intended as a speaker circuit. Three of the quads are used for communication between England and Ireland and the fourth quad contains circuits for the Isle of Man.

The circuits for Ireland pass through the Repeater Station at Port Erin and are continued in two unloaded, four-wire, balata-insulated cables, similar to each other in construction, also manufactured by Siemens Bros., and laid by the C.S. "Faraday" about the middle of June this year between Port Erin and Ballyhornan in Northern Ireland. (See Fig. 1). For half a naut. at each shore-end gutta-percha is substituted for balata for mechanical reasons. This type of cable has been used principally because of the unfavourable nature of the sea-bed and the adverse channel currents likely to be encountered.

The overall weight of each balata cable is 10.3 tons per naut., the dielectric being approximately 150 lbs. per naut. and the conductor 160 lbs. per naut.

The electrical characteristics of the above cables, taken from tests made after laying, are as follows:—

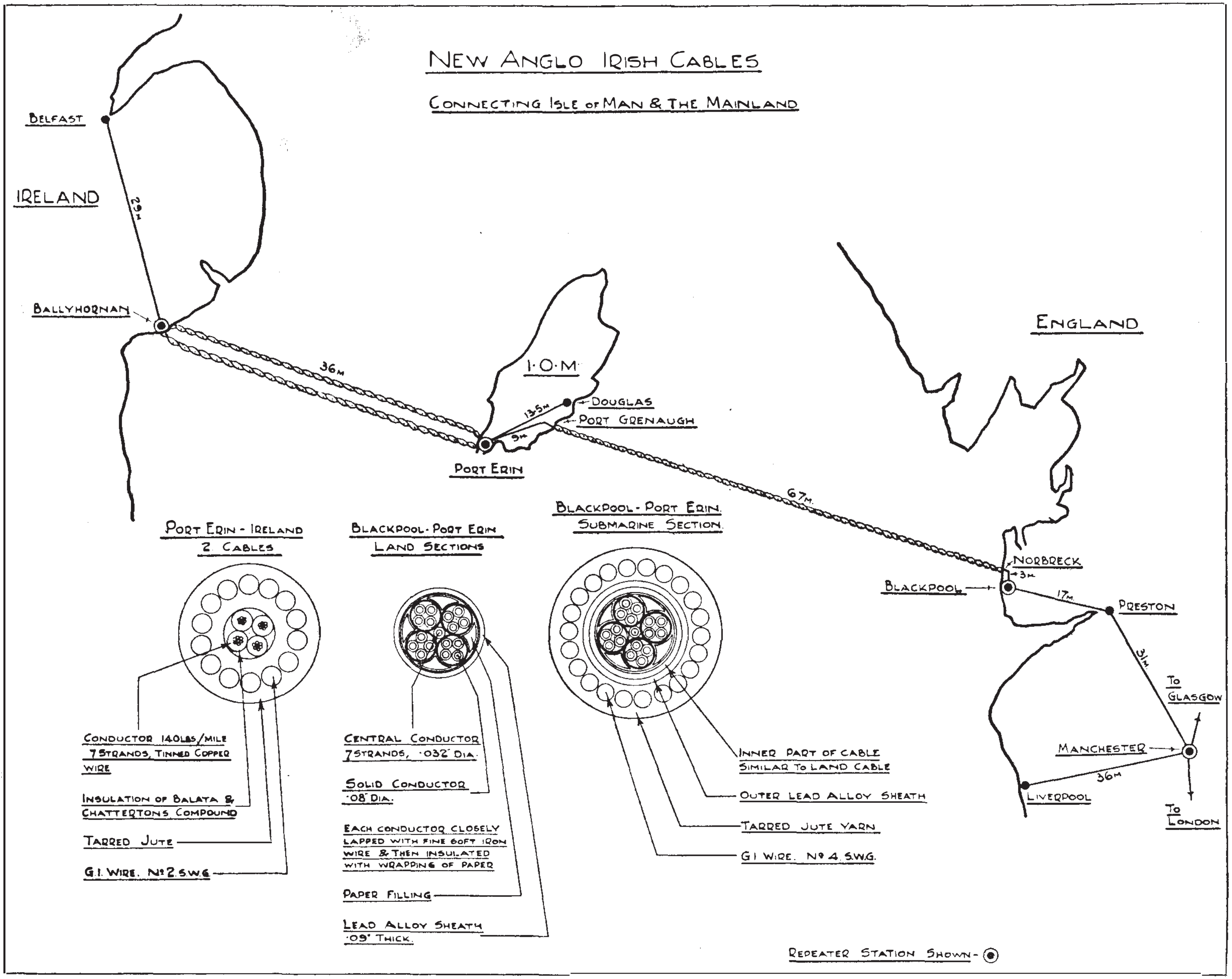

NEW ANGLO IRISH CABLES
CONNECTING ISLE OF MAN & THE MAINLAND
BELFAST
IRELAND
29M
BALLYHORNAN
36M
I·O·M
DOUGLAS
13·5M
PORT GRENAUGH
9M
PORT ERIN
67M
ENGLAND
NORBRECK
3M
BLACKPOOL
17M
PRESTON
31M
TO GLASGOW
MANCHESTER
36M
LIVERPOOL
TO LONDON
PORT ERIN - IRELAND 2 CABLES
CONDUCTOR 140LBS/MILE 7 STRANDS, TINNED COPPER WIRE
INSULATION OF BALATA & CHATTERTONS COMPOUND
TARRED JUTE
G.I. WIRE. Nº 2 S.W.G.
BLACKPOOL - PORT ERIN LAND SECTIONS
CENTRAL CONDUCTOR 7 STRANDS, ·032" DIA.
SOLID CONDUCTOR ·08" DIA.
EACH CONDUCTOR CLOSELY LAPPED WITH FINE SOFT IRON WIRE & THEN INSULATED WITH WRAPPING OF PAPER
PAPER FILLING
LEAD ALLOY SHEATH ·09" THICK.
BLACKPOOL - PORT ERIN. SUBMARINE SECTION.
INNER PART OF CABLE SIMILAR TO LAND CABLE
OUTER LEAD ALLOY SHEATH
TARRED JUTE YARN
G I WIRE. Nº 4. S.W.G.
REPEATER STATION SHOWN - ◉

FIG. 1.

BLACKPOOL-PORT ERIN CONTINUOUSLY-LOADED PAPER-CORE CABLE.

D.C. Tests.

From measurements made one month after laying, and with the cable terminated on Trunk Test Tablets at each end, the results obtained are:—

Average insulation resistance from tests on each of the 17 wires, against the others earthed, after 1 minute's electrification and with 220 volts
= 40,000 megohms per naut.

Average conductor resistance of 16 wires
= 19.7 ohms per naut. loop.

Conductor resistance of centre wire
= 8.74 ohms per naut.

Average side circuit capacity
= 0.094 μF. per naut. loop.

Average phantom circuit capacity
= 0.270 μF. per naut. loop.

A.C. Tests.

(*a*) *Transmission Efficiency and Distortion.*

The mean A.C. constants of all pairs and phantoms were calculated from measurements at a frequency of 800 c.p.s. and a testing current of 1 mA. The results are given in Table I.

TABLE I.

BLACKPOOL-PORT ERIN SUBMARINE TELEPHONE CABLE.
MEAN A.C. CONSTANTS AT f = 800 C.P.S.
LENGTH OF CABLE = 69.1 NAUTICAL MILES.

Circuit.	Characteristic Impedance, vector ohms.	Attenuation, Constant Neper per naut. loop.	Propagation, Constant per naut. loop.	Effective Resistance, ohms per naut. loop.	Inductance, mhys. per naut. loop.	Capacity, μF. per naut. loop.
	$Z_0 \lvert \phi_0$	β	γ/θ	R	L	C
Mean of 8 pairs	$377 \lvert 8°50'$	0.0287	$0.171 \lvert 80°20'$	20.4	12.2	0.090
Mean of 4 phantoms	$155 \lvert 9°23'$	0.0348	$0.201 \lvert 80°\ 2'$	10.3	5.9	0.258
Centre wire-earth return (tested from Port Erin)	$246 \lvert 8°\ 9'$	0.0254	$0.184 \lvert 82°56'$	—	—	0.145

From Table I. it will be seen that each side circuit is equivalent to approximately 18.5 M.S.C. and each phantom circuit to 22.5 M.S.C. The centre wire-earth return circuit is equivalent to nearly 16.5 M.S.C., but it forms a bad speaker circuit owing to noise produced from extraneous sources, of which the principal is that part of the Blackpool Tramway System which runs parallel with the land portion of the cable for nearly two miles towards Norbreck.

The variation of attenuation with frequency for a selected pair is given in Fig. 2 together with the corresponding variation for a selected phantom circuit. From these curves the total distortion from f = 400 c.p.s. to f = 2000 c.p.s. is

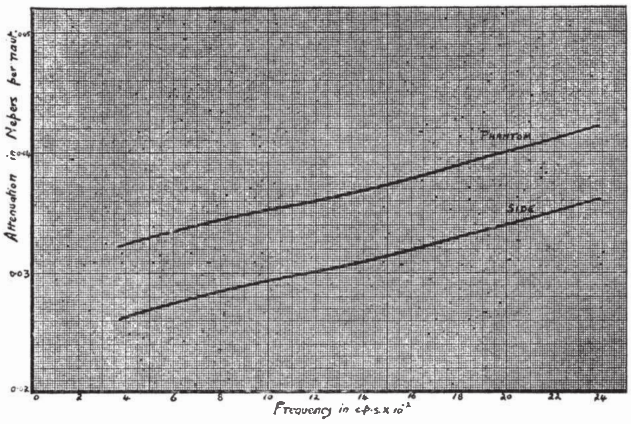


FIG. 2.—ATTENUATION - FREQUENCY CHARACTERISTICS FOR SIDE AND PHANTOM CIRCUITS: BLACKPOOL-PORT ERIN CABLE.

found to be about 5 M.S.C. for the side circuits and 5 M.S.C. for the phantom circuits.

(b) Uniformity of Electrical Constants.

The characteristic impedance of each side circuit was measured over a range of frequency from 300 c.p.s to 3000 c.p.s and they all have similar characteristics. A typical example of the variation of the impedance components with frequency is given in Fig. **3**, the dotted curve being that calculated for an imaginary cable having a perfectly uniform distribution of resistance, capacity and inductance throughout its length equal per naut. to the mean constants per naut. for that circuit obtained by measurement on it. It is interesting to note that the slight undulation of the measured characteristic about the hypothetical mean is roughly of a periodicity equal to 2000 c.p.s., which indicates a reflection effect at a distance of about 7½ nauts. from Port Erin, *i.e.*, where the sea and land cables are joined. This effect is largely brought about by the difference in temperature between land and sea causing a difference between the electrical constants of the land and sea portions of the complete cable and its magnitude will vary with the season of the year.

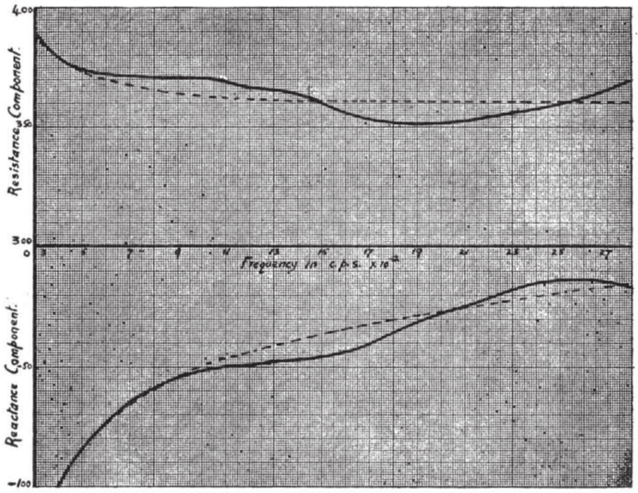


Fig. **3**.—Typical Impedance-Frequency Characteristics for Side Circuits of the Blackpool-Port Erin Cable.

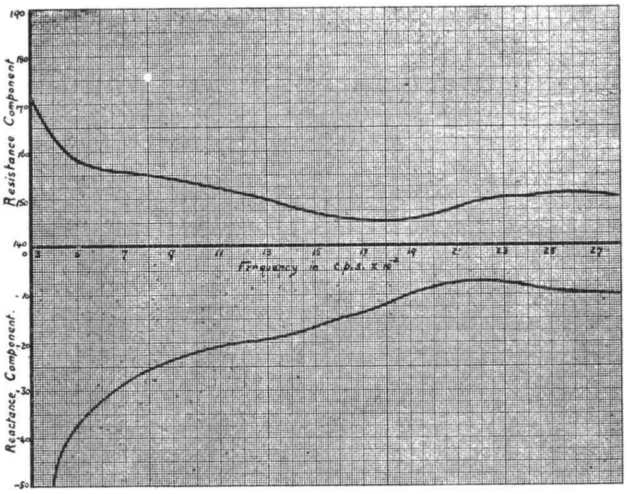


Fig. **4**.—Typical Impedance-Frequency Characteristics for Phantom Circuits of the Blackpool-Port Erin Cable.

Fig. **4** shows the impedance components plotted against frequency for one of the phantom circuits (taken from tests made on the four phantoms), all of which are similar in shape. It will be seen that the electrical constants of all circuits in the quads are satisfactorily uniform, as far as these characteristics are concerned.

(c) Interference between Circuits.

Cross-talk measurements were made on an equivalent current basis with the P.O. apparatus, using a Western Electric Cross-Talk Meter, which expresses the induced current in millionths of the inducing current. The meter readings obtained with speech as the source of disturbance are given in Table II. together with particulars of the testing conditions.

TABLE II.

BLACKPOOL-PORT ERIN CONTINUOUSLY-LOADED CABLE.
CROSS-TALK WITHIN QUADS MEASURED WITH P.O. APPARATUS.

Meter readings taken with the distant end of cable closed through repeating coils by its characteristic impedance. Meter in parallel.

AB ≡ red-white pair of the quad.
CD ≡ blue-white pair ,, ,, ,,
+ ≡ phantom circuit ,, ,, ,,

Source of Disturbance—Speech.

Tests from Blackpool Repeater Station.					Tests from Port Erin Repeater Station.				
Speak on		Listen on			Speak on		Listen on		
Quad	Cct.	AB	CD	+	Quad.	Cct.	AB	CD	+
Red	AB	—	100	250	Red	AB	—	70	200
	CD	100	—	300		CD	70	—	160
	+	350	350	—		+	350	200	—
Blue	AB	—	70	350	Blue	AB	—	100	200
	CD	70	—	500		CD	100	—	250
	+	500	700	—		+	300	400	—
White	AB	—	100	500	White	AB	—	100	200
	CD	100	—	700		CD	100	—	300
	+	700	1000	—		+	300	450	—
Green	AB	—	70	350	Green	AB	—	80	250
	CD	70	—	300		CD	80	—	200
	+	550	450	—		+	450	300	—

In Table III. these results are expressed in népers, after a correction made to allow for the difference in impedance between the disturbed and disturbing circuits and the terminal apparatus.*

TABLE III.

BLACKPOOL-PORT ERIN CONTINUOUSLY-LOADED CABLE.
CROSS-TALK WITHIN QUADS EXPRESSED IN NEPERS—
After correction to allow for end apparatus and different circuit impedances.

Source of Dsiturbance—Speech. Conditions of test as for Table II.

Tests from Blackpool Repeater Station.					Tests from Port Erin Repeater Station.				
Speak on		Listen on			Speak on		Listen on		
Quad	Cct.	AB	CD	+	Quad	Cct.	AB	CD	+
Red	AB	—	9.4	8.7	Red	AB	—	9.8	8.8
	CD	9.4	—	8.6		CD	9.8	—	9.2
	+	8.7	8.7	—		+	8.7	9.2	—
Blue	AB	—	9.8	8.2	Blue	AB	9.4	9.4	8.8
	CD	9.8	—	7.9		CD	—	—	8.7
	+	8.3	8.0	—		+	8.9	8.6	—
White	AB	—	9.4	7.9	White	AB	—	9.4	8.8
	CD	9.4	—	7.5		CD	9.4	—	8.6
	+	8.0	7.7	—		+	8.9	8.5	—
Green	AB	—	9.8	8.2	Green	AB	—	9.7	8.7
	CD	9.8	—	8.6		CD	9.7	—	9.0
	+	8.2	8.5	—		+	8.5	8.9	—

---

* *See paper by Dr. A. Rosen, Journal I.E.E., page 349, Vol. 64, August, 1926*

The cross-talk readings obtained, using the P.O. apparatus and W.E. Cross-Talk Meter, when speaking on the centre wire and earth circuit and listening on the other circuits of the cable, are shown in Table IV., expressed in népers. *The cross-talk between circuits of the different quads* is greater than 10.5 népers in all cases.

TABLE IV.

CROSS-TALK BETWEEN CENTRE WIRE-EARTH RETURN CIRCUIT AND THE QUAD CIRCUITS.

Expressed in népers. Meter in parallel. Circuits closed by their characteristic impedances at the distant end.
Source of Disturbance—Given in Column No. 1.

Speak on Centre Wire—Earth Return At :—	Listen in											
	Red Quad			Blue Quad			White Quad			Green Quad		
	AB	CD	+	AB	CD	+	AB	CD	+	AB	CD	+
Blackpool (Reed Hummer)	8.2	7.8	8.1	9.2	7.6	7.6	8.1	7.8	7.1	7.8	8.1	7.1
Port Erin (Speech)	8.5	8.5	7.8	8.7	8.7	7.8	8.9	8.7	7.6	8.9	8.7	7.8

PORT ERIN-BALLYHORNAN BALATA-INSULATED CABLES. NO. 1 (NORTHERN) AND NO. 2 (SOUTHERN).

The data given is that obtained from tests on No. 1 Cable except for the case of insulation resistance, the corresponding figures obtained for No. 2 Cable being the same in the other cases.

D.C. Tests.

Average insulation resistance of each wire of No. 1 Cable, to remaining wires earthed, tested with 500 volts after 1 minute's electrification and corrected to 75°F.

= 700 megohms per naut.

Average insulation resistance of each wire of No. 2 Cable, to remaining wires earthed, tested with 500 volts after 1 minute's electrification and corrected to 75°F.

= 900 megohms per naut.

Average conductor resistance of each wire = 7.0 ohms per naut.

Average capacity of each wire to the other wires earthed

= 0.315 μF. per naut.

A.C. Tests.

(*a*) *Transmission Efficiency and Distortion.*

The mean A.C. constants calculated for $f=800$ c.p.s. for the side and phantom circuits are shown in Table V.

TABLE V.

PORT ERIN-BALLYHORNAN BALATA CABLES.
MEAN A.C. CONSTANTS AT $f = 800$ C.P.S.
LENGTH OF EACH CABLE ≒ 32 NAUTICAL MILES.

Circuit	Characteristic Impedance	Attenuation Constant per naut. loop.	Propagation Constant per naut. loop.	Effective Resistance, ohms per naut. loop.	Capacity μF. per naut. loop.
	Z_0 vector ohms	β	$\gamma\|\underline{\theta}$	R	C
Side	$149\overline{\|27^\circ 52'}$	0.056	$0.116\underline{\|60^\circ 55'}$	14.5	0.156
Phantom	$70.4\overline{\|32^\circ 32'}$	0.059	$0.120\underline{\|60^\circ 34'}$	7.5	0.340

From this table it will be seen that each side circuit is equivalent to approximately 17 M.S.C. and each phantom circuit to nearly 18 M.S.C.

The variation of the attenuation constant with frequency can be seen from Table VI., and these figures give the total distortion from $f = 400$ c.p.s. to $f = 2000$ c.p.s. as approximately 6 M.S.C. for the side circuit and 7.5 M.S.C. for the phantom circuit. It is interesting to compare the above values for M.S.C. with the corresponding values for the paper-core loaded cable which is more than twice the length of each of the unloaded balata cables and has a much smaller conductor.

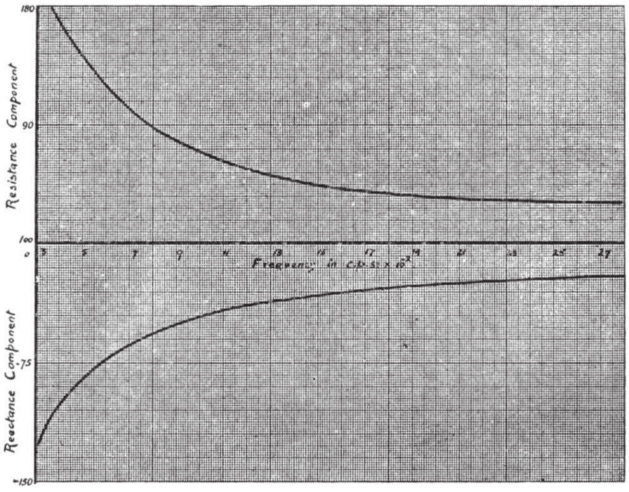


FIG. 5.—TYPICAL IMPEDANCE-FREQUENCY CHARACTERISTICS FOR SIDE CIRCUITS OF THE BALLYHORNAN-PORT ERIN BALATA CABLES.

TABLE VI.

PORT ERIN-BALLYHORNAN BALATA CABLES.
EXAMPLE OF CHANGE OF ATTENUATION CONSTANT WITH FREQUENCY.

Frequency c.p.s. f	Side Circuit. Attenuation Constant. Népers per naut. loop. β.	Phantom Circuit. Attenuation Constant. Népers per naut. loop. β.
400	0.044	0.046
800	0.054	0.059
1200	0.059	0.066
1600	0.063	0.070
2000	0.064	0.071
2400	0.067	0.075

(b) *Uniformity of Electrical Constants.*

The characteristic impedance of each side and phantom circuit was measured over a range of frequency from 300 c.p.s. to 3000 c.p.s. and Fig. **5** is a typical example of the variation of the impedance components with frequency for the side circuits, while Fig. **6** is a corresponding example for the phantom circuits. All these curves are smooth curves, showing that the cables have practically an absolutely uniform distribution of electrical constants.

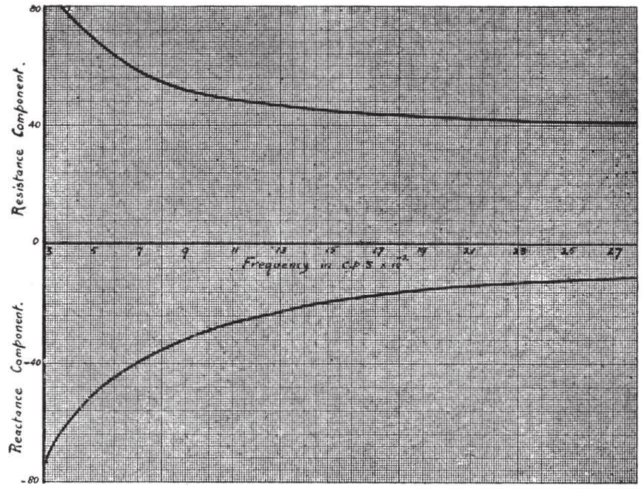


FIG. **6**.—TYPICAL IMPEDANCE-FREQUENCY CHARACTERISTICS FOR PHANTOM CIRCUITS OF THE BALLYHORNAN-PORT ERIN BALATA CABLES.

(c) *Interference between Circuits.*

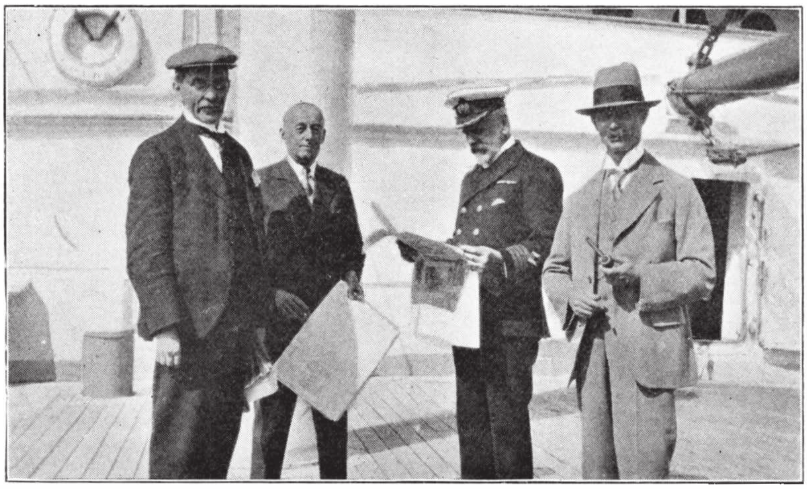
Cross-talk measurements were made with speech as the source of disturbance in the same manner as those on the Blackpool-Port Erin continuously-loaded cable and a summary of the results taken from Port Erin is as follows—all the readings obtained being also corrected and converted to népers :—

Maximum side-to-side cross-talk units obtained with speech = 40 ≒ > 10.5 corrected népers.

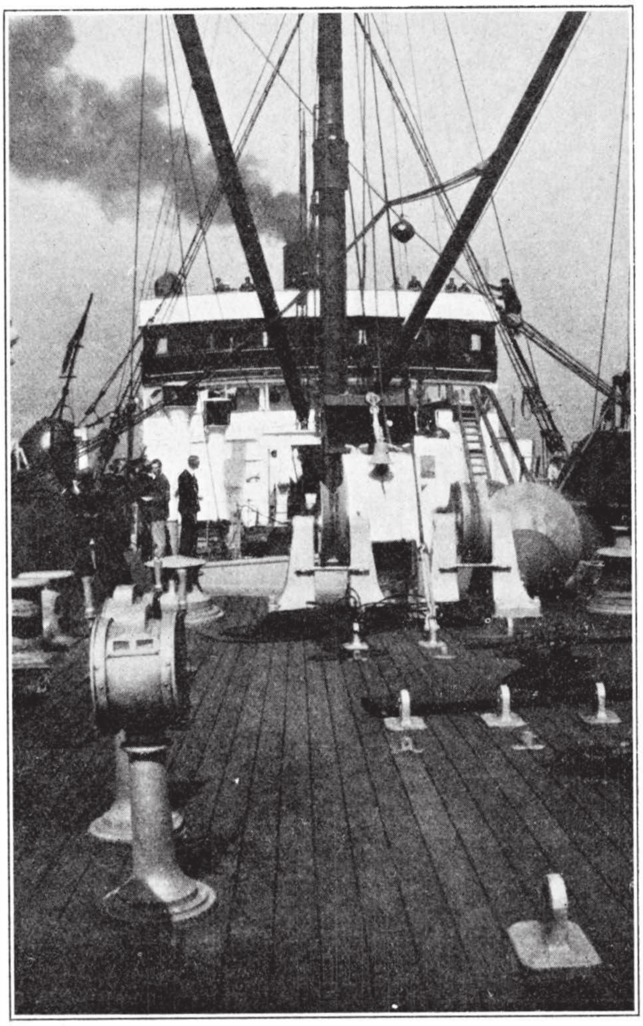
Maximum phantom-to-side cross-talk units obtained with speech = 300 ≒ 9.0 corrected népers.

Cross-talk between circuits in the two different cables obtained with speech < 20 units ≡ > 11.0 népers.

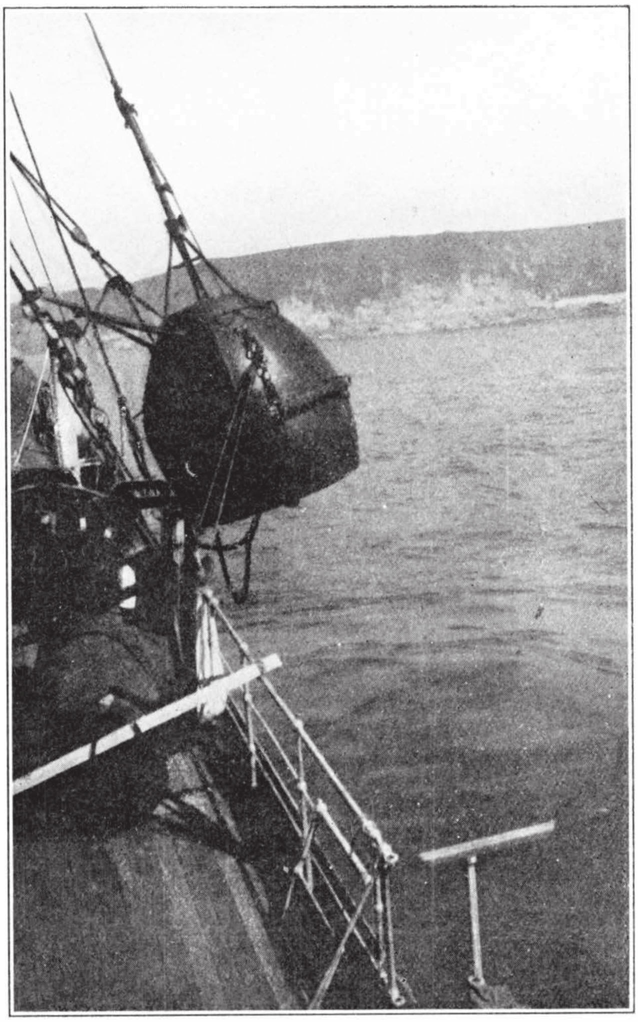
In conclusion, some interesting photographs are given on pages 203, 204, and 205, showing various operations during the laying of these submarine cables and taken by Messrs. Siemens Bros. representative on board the C.S. "Faraday."



Mr. Medlyn. Mr. Dudley Stuart. Captain Bourdeaux. Mr. De Lattre.
On board "Faraday."

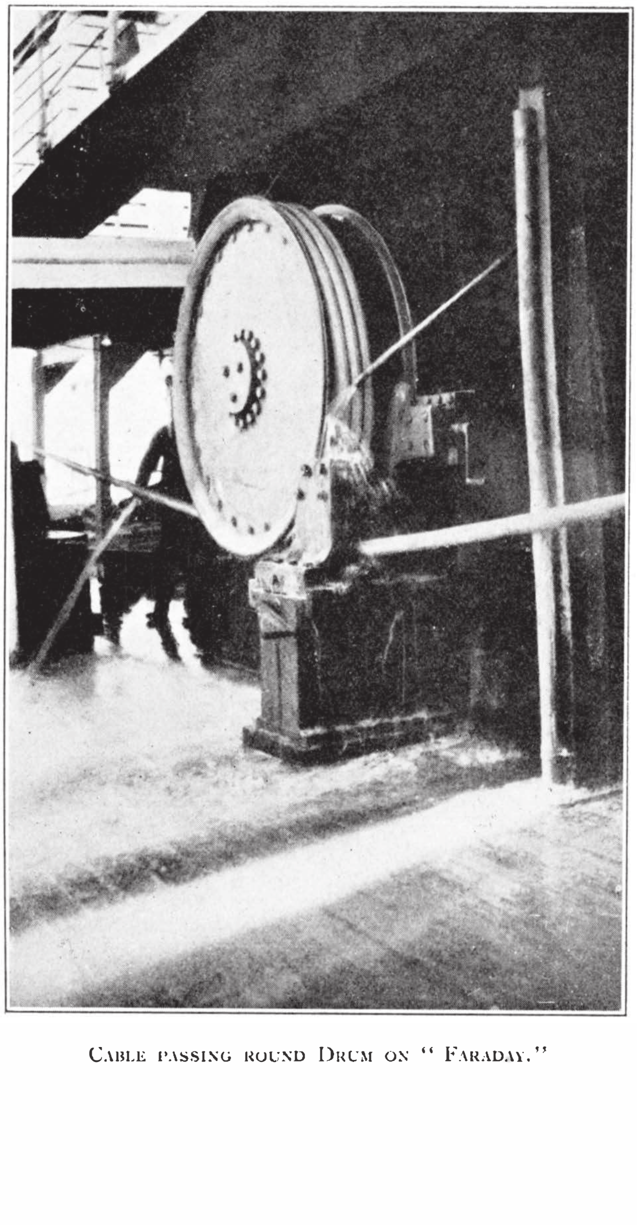


Deck of "Faraday."

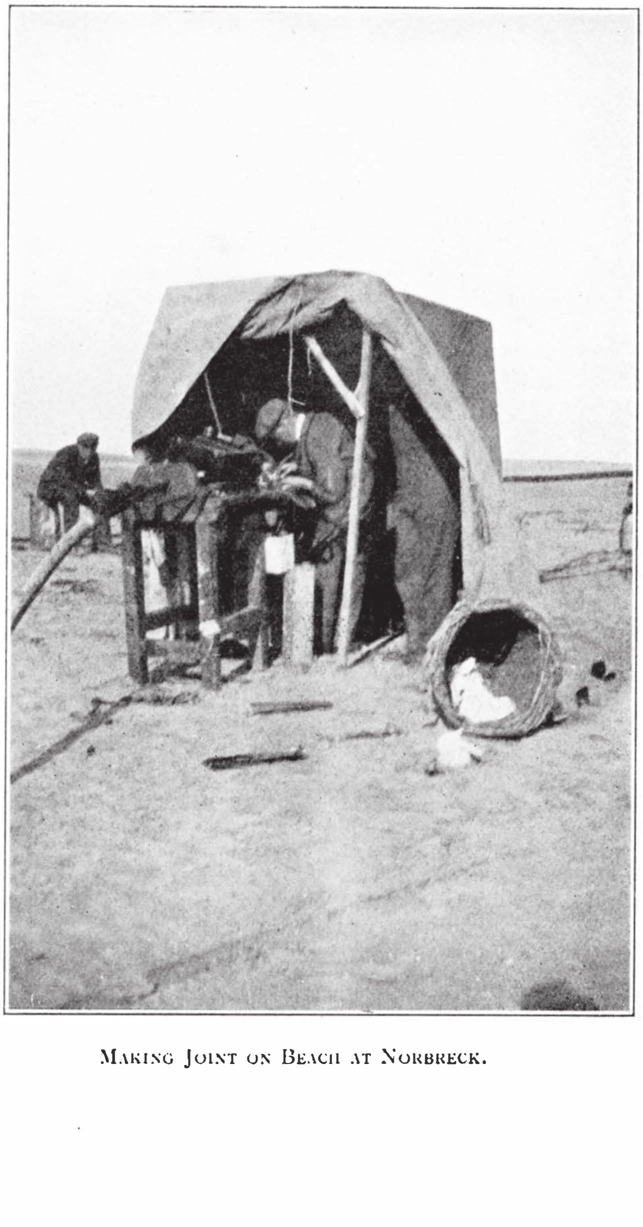


Lowering a Mark Buoy.

C.S. " Faraday " off Port Grenaugh.

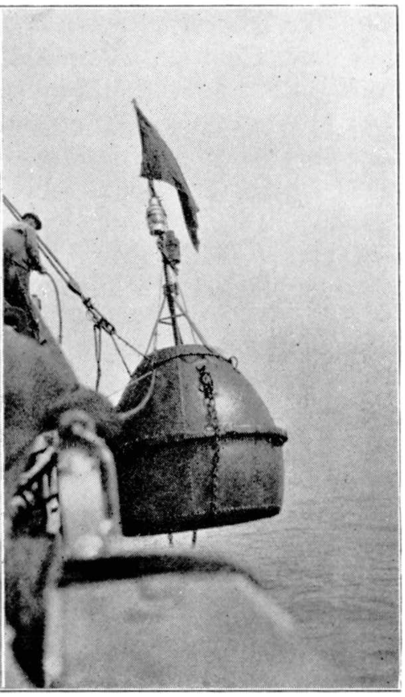


Cable passing round Drum on " Faraday."



Making Joint on Beach at Norbreck.

Captain Allan, of C.S. "Farraday."



Lowering a Mark Buoy.

MECHANICAL AIDS TO WORKS OF UNDERGROUND CABLING.

J. R. M. Elliott.

THE increasing uses to which motor vehicles are being utilized throughout the country, and their profitable application to engineering operations open out possibilities for extending the employment of mechanical aids to our works of external construction.

The initial outlay and the high charges for petrol associated with motor vehicles may in the past have hindered progress in this direction, and whilst it may be necessary to exercise caution in expenditure on mechanical appliances the time has arrived when their use may with advantage be extended on works of external construction, particularly those of a heavy character such as underground cabling operations.

Some months ago, an extensive programme of underground cabling was contemplated in the Northern District, and special investigation was made locally into methods of carrying out the work in the most economical manner. Important factors in the cost of this class of work are usually the operations associated with drawing in cable, local haulage of drums, setting them up on jacks, and moving forward from point to point the various items of plant and tools. The motor winches, limited in number, for loan to Districts, were all in use at different centres at the time, and there was no guarantee that our demands in this direction could be met when cables came to hand, in which case the normal course would have been to pursue operations with hand winches. Necessity is the mother of invention, however, and consideration was focussed on the possibility of introducing mechanism for the purpose, which could be coupled to the engines of the lorries accompanying cabling gangs. At the same time, it was considered that if a suitable float could be constructed for conveying the drums of cable from the Goods Station, or other point of delivery, to the manholes where the cables were required, and if this vehicle could be towed by the lorry, a good deal of manual work would be eliminated, and the ineffective costs would be cut down.

Efforts were first directed to the design and construction of a float, and before long a vehicle, which has since come to be known as a " Cable Bogie " was evolved and built in the local workshops. The problem was not without its difficulties. In the first place, the vehicle had to be designed for the conveyance of weights in the neighbourhood of $3\frac{1}{2}$ tons; it had therefore to be strongly built; the clearance between the body and the ground had to be as little as possible; the forecarriage had to be high enough to be coupled to a 3-ton lorry; the body had to be of sufficient width to receive the widest drums without transgressing the Police regulations; the tyres had to be of solid rubber to permit a trailing speed of 10 miles per hour; the overall dimensions had to be restricted to permit it being placed on footpaths; and it had to conform to the regulations in the matter of brakes and other adjuncts.

When the completed bogie was brought into use, each thoroughfare seemed to bring its own particular trouble. By concentration of careful study on individual requirements, as they arose from time to time, modifications and refinements were applied in the workshop until the carrier met all the conditions likely to be encountered in the District.

A second bogie, embodying all the latest improvements, was recently introduced and is in regular use. Fig. **1** shows the constructional details.

The bogie consists essentially of a low float with facilities for loading the cable drums for transport and jacking them up for paying off the cable when placed in position over the manhole. The leading dimensions were fixed by consideration of the size of the largest cable drum likely to be used.

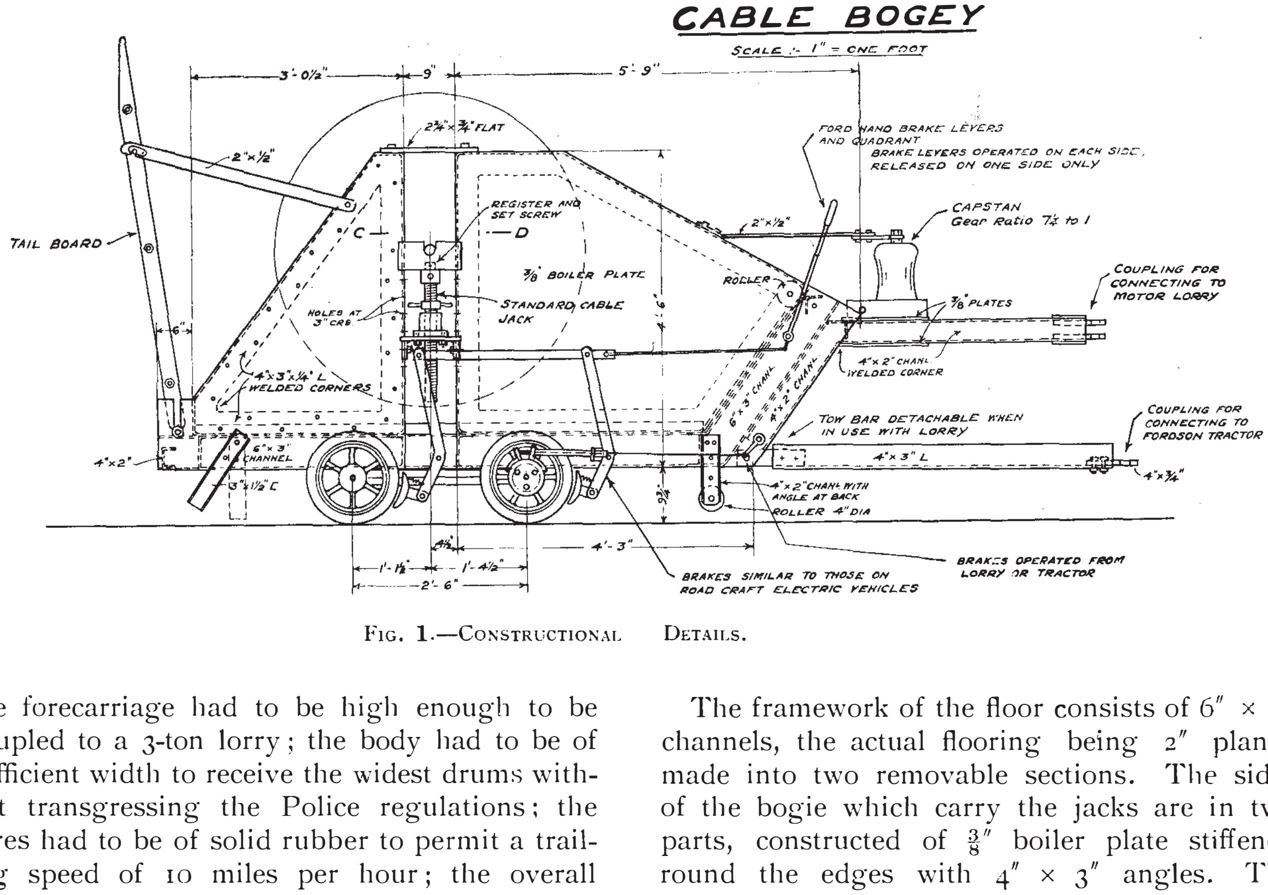

CABLE BOGEY
SCALE :- 1" = ONE FOOT
3'-0½"
9"
5'-9"
2¾"×¾" FLAT
2"×½"
TAIL BOARD
C
D
REGISTER AND SET SCREW
⅜" BOILER PLATE
STANDARD CABLE JACK
HOLES AT 3" CRS
4'-6"
6"
4"×3"×¼" L WELDED CORNERS
4"×2"
6"×3" CHANNEL
3"×1½" C
9¾"
4½"
4'-3"
1'-1½"
1'-4½"
2'-6"
FORD HAND BRAKE LEVERS AND QUADRANT
BRAKE LEVERS OPERATED ON EACH SIDE, RELEASED ON ONE SIDE ONLY
2"×½"
CAPSTAN Gear Ratio 7¼ to 1
ROLLER
⅜" PLATES
COUPLING FOR CONNECTING TO MOTOR LORRY
4"×2" CHANL WELDED CORNER
6"×3" CHANL
4"×2" CHANL
TOW BAR DETACHABLE WHEN IN USE WITH LORRY
COUPLING FOR CONNECTING TO FORDSON TRACTOR
4"×3" L
4"×¾"
4"×2" CHANL WITH ANGLE AT BACK
ROLLER 4" DIA
BRAKES OPERATED FROM LORRY OR TRACTOR
BRAKES SIMILAR TO THOSE ON ROAD CRAFT ELECTRIC VEHICLES

FIG. 1.—CONSTRUCTIONAL DETAILS.

The framework of the floor consists of 6″ × 3″ channels, the actual flooring being 2″ planks made into two removable sections. The sides of the bogie which carry the jacks are in two parts, constructed of $\frac{3}{8}$″ boiler plate stiffened round the edges with 4″ × 3″ angles. The vertical angles of the sides form guides for the castings made to take the ends of the spindles and also take the seatings of the jacks. A series of holes spaced 3″ apart in the flanges of these angles gives a ready method of adjusting the height of the jack to suit any particular drum. Standard cable jacks adapted, as required, to suit the bogie are used. The tail board, which

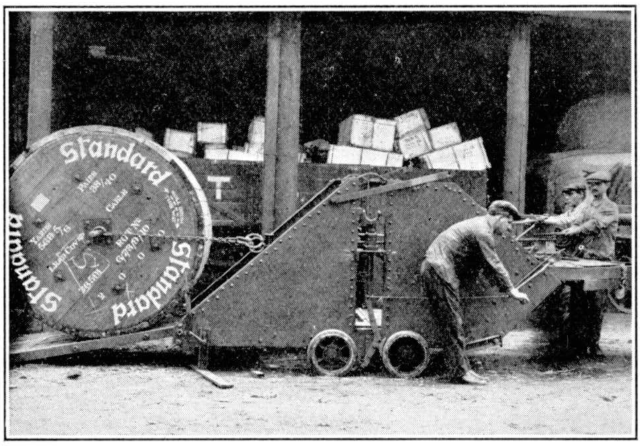


FIG. **2**.—LOADING DRUMS AT GOODS STATION.

is of heavy construction to withstand the wear and tear to which it is subjected, is made of 3″ planks with a R.S.J. as a centre stiffener and channel iron round the edges. The tailboard is hinged to the back by means of slots in an extension of the plate forming the sides. When lowered, this tailboard forms a ramp up which cable drums are drawn on to the bogie, by means of a hand worked capstan operated by wormgear of $7\frac{1}{4}$ to 1 reduction.

The axles are fixed, and to keep down expense old Ford axles coupled with compression couplings have been used. To facilitate loading of drums on to the lorry, the floor level is kept as low as possible consistent with safety and steel cast wheels of 12″ diameter with phosphor bronze bearings and solid rubber tyes have been used. The wheel base is only 2′ 6″ and this avoids undue wear and tear on the tyres when cornering. A 4″ diameter steel roller is secured at the front end to take any jolt which may occur from unevenness of the road surface.

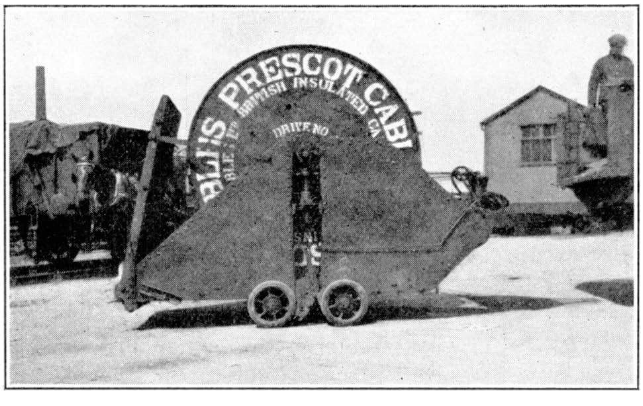


FIG. **3**.—BOGIE LOADED AND READY TO BE COUPLED TO LORRY.

Two sets of brakes are provided. One set is operated from levers on either side of the front end which applies all four brakes with the one action, the brakes acting on the tyres. The other set, on the band brake principle, operates on the two front wheels only, and is so placed that by connecting up a cable they may be operated from the towing lorry. When a Fordson tractor is employed for towing purposes a special coupling, which is removable, as shown in Fig. **1**, is used.

The heaviest drums of cable issued can be drawn on to the bogie by three men, two of whom operate the hand worked capstan and the third the guiding tackle. Fig. **2** shows a loaded drum, weighing $2\frac{1}{2}$ tons, being drawn up the tailboard, which, when let down, is used as a ramp. The brakes are very effective, and when applied they dispense with the necessity for anchoring the vehicle. The short struts or feet at the rear, the off side one of which is shown in the photograph, prevent tilting as the load approaches the body, and when the drum is housed on the adjustable jacks the struts are thrown out of use by giving them a quarter turn and clamping them with the small handle shown.

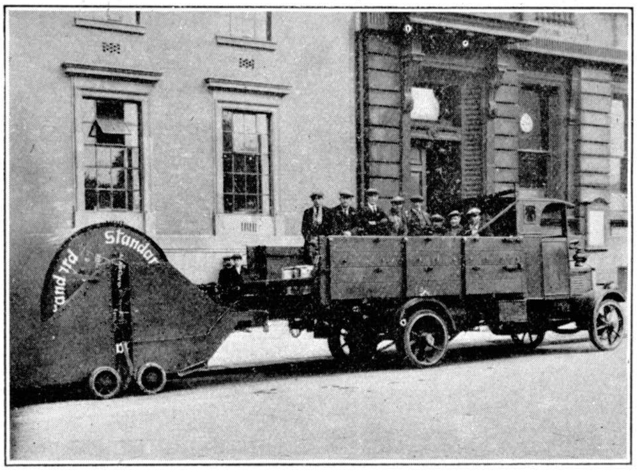


FIG. **4**.—LOADED BOGIE COUPLED TO LORRY.

Fig. **3** shows the bogie loaded and ready to be coupled to the lorry. This operation is effected by backing the lorry to the bogie and inserting a coupling pin. Fig. **4** shows the bogie coupled to the lorry, which has on board the cabling gang and the essential plant and tools, the combination being ready to move off to the site of work.

For placing the bogie in position for paying off on a footpath, $4\frac{1}{2}$ feet lengths of 6″ channel iron are placed as a track for the wheels, in order to distribute the weight and thus avoid damage to the pavement. The bogie is then tugged into position by a rope from the lorry like a ship being berthed by a tug boat; Fig. **5** shows the drum ready for paying off. The brakes are applied, the wheels are in the channel iron, both front and rear feet are let down to steady the vehicle, and the jacks are suitably raised to lift the drum clear of the floor. In this case the cable is to be paid off through an aperture in the floor, but when necessary the tailboard can be detached to permit of the cable being paid off clear of the vehicle, as in Fig. **6**. Where it is not convenient to take the bogie on to the footpath it can be placed on the road.

In cases where more than one length is contained on a drum, re-battening for transport to another site, and taking the battens off again on arrival there is avoided, and much ineffective time is thus eliminated. The cost of a bogie is about £120.

For the purpose of ascertaining the extent of the saving in costs by the use of the bogie, records were carefully kept and figures for six consecutive weeks ended 28th September last year were obtained and are shown in Schedule A.

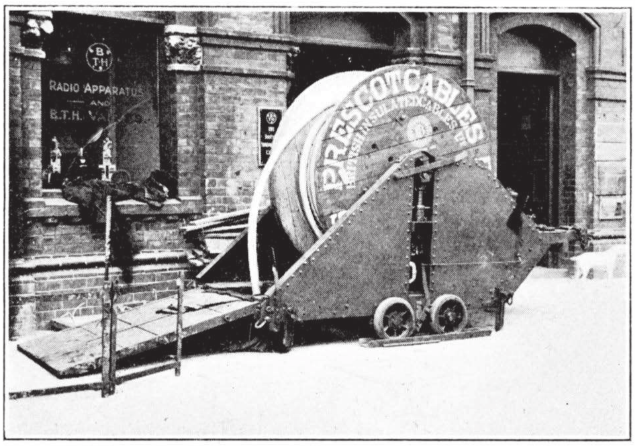


FIG. **5**.—BOGIE WITH DRUM IN POSITION OVER MANHOLE ON WIDE FOOTPATH.

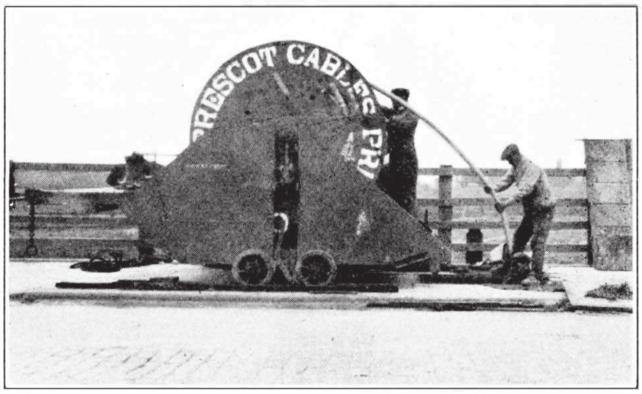


FIG. **6**.—PAYING-IN FROM BOGIE ON NARROW FOOTPATH.

CABLE DRUM CARRIAGE IN CONJUNCTION WITH 3 TON LORRY.

Schedule showing Actual Costs as compared with Provincial Average Rates.

Dargue's gang.

Schedule

	Week Ending 24th Aug., 1928.		Week Ending 31st Aug., 1928		Week Ending 7th Sept., 1928		Week Ending 14th Sept., 1928		Week Ending 21st Sept., 1928		Week Endin 28th Sept., 19	
Length & Type of Cable	Yds. 5101 38/40 Gp.2		Yds. 498 50/10 Gp.1 1069 54/40 Gp.3		Yds. 3628 38/40 Gp.2 2023 54/40 Gp.3		Yds. 4474 54/40 Gp.3		Yds. 273 122/40 Gp.3 2492 54/40 Gp.3		Yds. 213 38/10 Gp. 414 38/40 Gp. 1397 122/40 G	
	Actual M.Hrs.	P.A. Rates	Actual M.Hrs.	P.A. Rates	Actual M.Hrs.	P.A. Rates	Actual M.Hrs.	P.A. Rates	Actual M.Hrs.	Rates P.A.	Actual M.Hrs.	P.A Rat
Effective Manhours:												
Cable drawn in	196	696	113	311	203	993	211	1100	151	680	227	42
Ineffective Time	103	196	33	70	98	267	38	148	$70\frac{1}{2}$	162	86	14
Total M. Hrs.	299	892	146	381	301	1260	249	1248	$221\frac{1}{2}$	842	313	56
	at $1/3\frac{3}{4}$	at $1/3\frac{3}{4}$										
Cost at Average Rate	£19 12 0	£58 11 0	£9 11 0	£25 0 0	£19 15 0	£82 14 0	£16 8 0	£82 0 0	£14 11 0	£55 5 0	£20 10 0	£37
Cost of 3 ton Lorry	£9 10 0		£6 0 0		£12 12 0		£14 7 0		£9 10 0		£8 18 0	
Estimated Cartage		£9 0 0		£8 0 0		£13 15 0		£12 16 0		£7 11 6		£7 1
Total	£29 2 0	£67 11 0	£15 11 0	£33 0 0	£32 7 0	£96 9 0	£30 15 0	£94 16 0	£24 1 0	£62 16 6	£29 8 0	£44 1
Net Saving	£38 9 0		£17 9 0		£64 2 0		£64 0 0		£39		£15 8 0	

The costs for the 3 ton lorry are those taken from the official returns, and the costs for cartage are estimated sums based on similar work prior to the advent of the bogie. The P.A. rates shown were those in force at the time of the trial. It will be seen that for one gang alone the net saving for the period under review amounted to the sum of £238 8s. od.

The 3 ton lorries are not always available for cable gangs, and during one period when all the lorries were in use for their legitimate purposes of transporting stores, a Fordson Tractor, the hire of which was less than a 3 ton lorry, was used successfully for towing the bogie. The use of a Fordson made it necessary to fit a special coupling of a temporary character. The photograph shows also the roller under the front end of the bogie, which is essential when the vehicle is being wheeled from the roadway to the footpath, in order to take the weight of the end protruding over the latter.

The economy which was effected by the use of the bogie encouraged the efforts which were being made in designing and constructing a capstan to be operated by the engine of a 3 ton Albion lorry. The drive for the capstan, a detailed drawing of which is shown in Fig. **7**, is taken direct from the propeller shaft by a chain drive through a lay shaft and worm gear. A dry ferrodo clutch operated by a foot pedal is used for the final drive to the worm gear, this being so arranged that the capstan is disconnected unless the foot pedal is depressed.

Two 4″ × 3″ R.S.Js. secured to the longitudinal frame members carry the capstan mounting and also the bronze bearings for the lay shaft, while a 5″ × 3″ angle iron secured to the floor carries the bearings for the clutch shaft and for the pedal. The 4″ × 3″ R.S.Js. are only 7″ centres, so that no trouble is experienced from frame distortion. The capstan itself was cast to suit requirements, a steel sleeve being inserted at the top and bottom to take the roller bearings used. A standard 1½″ thrust ball bearings takes the weight of the capstan.

In operation the engine of the lorry is set to run at a speed of about 325 r.p.m., and the chain drive and worm reduction gives a capstan speed of 13 r.p.m., that is, a drawing-in speed of about 27 ft. per minute. The engine clutch is not disconnected while driving the capstan, but the engine runs in neutral gear. The foot pedal clutch for operation of the capstan is designed to slip at a maximum of 8 h.p. with normal pressure on the foot pedal, so that at the speed given the pull is more than sufficient to deal with the heaviest cable without in any way overloading the engine.

After taking the bogie into the required position for paying off the cable, the lorry proceeds to the drawing-in points. One man, the lorry driver, who watches the signals from a distant point, controls, with his foot, the starting clutch. Withdrawal of his foot releases the clutch and the capstan instantly stops. A second man is in charge of the rope, which in passing from the duct to the capstan, rides over the roller at the back of the lorry. In this case it has been possible to place the lorry immediately over the manhole, but sometimes the conditions are such that the lorry has to operate some distance away.

The hand brake of the vehicle is sufficient to anchor the lorry against the heaviest strain. When necessary a man is stationed in the manhole to keep an eye on the rope as it emerges from the duct or pipe, and the rate of drawing-in is dependent upon the celerity with which the petroleum jelly can be applied to the cable at the distant end. The speed of the bollard can be adjusted by varying the throttle control of the engine. The cost of constructing and fitting a capstan is about £30. The lorry is used for the accommodation of plant, stores and tools, and this enables the footpath to be kept clear of the usual paraphernalia associated with a cabling gang. In busy thoroughfares this is a matter of some importance as the obstruction to traffic is minimised. At the outcoming end a cable guard only is necessary, as the lorry is used for storage, and, similarly, at the paying-in end a cable-guard only, in addition to the bogie, is required.

In shifting to a new site, the men are conveyed in the lorry and are saved the laborious task of packing up and pushing a handcart. They are thus less fatigued and are ready to resume operations immediately on arrival at the next point. A tool cart is unnecessary and the ineffective time usually inseparable from packing up at the end of a day's work and seeking a safe place for storage purposes is avoided.

For the four consecutive weeks ended 16th November last year, special records were kept of the costs associated with the gang using a lorry fitted with a capstan, and a comparison between the figures obtained and the standard rates which prevailed at the time are given in Schedule B.

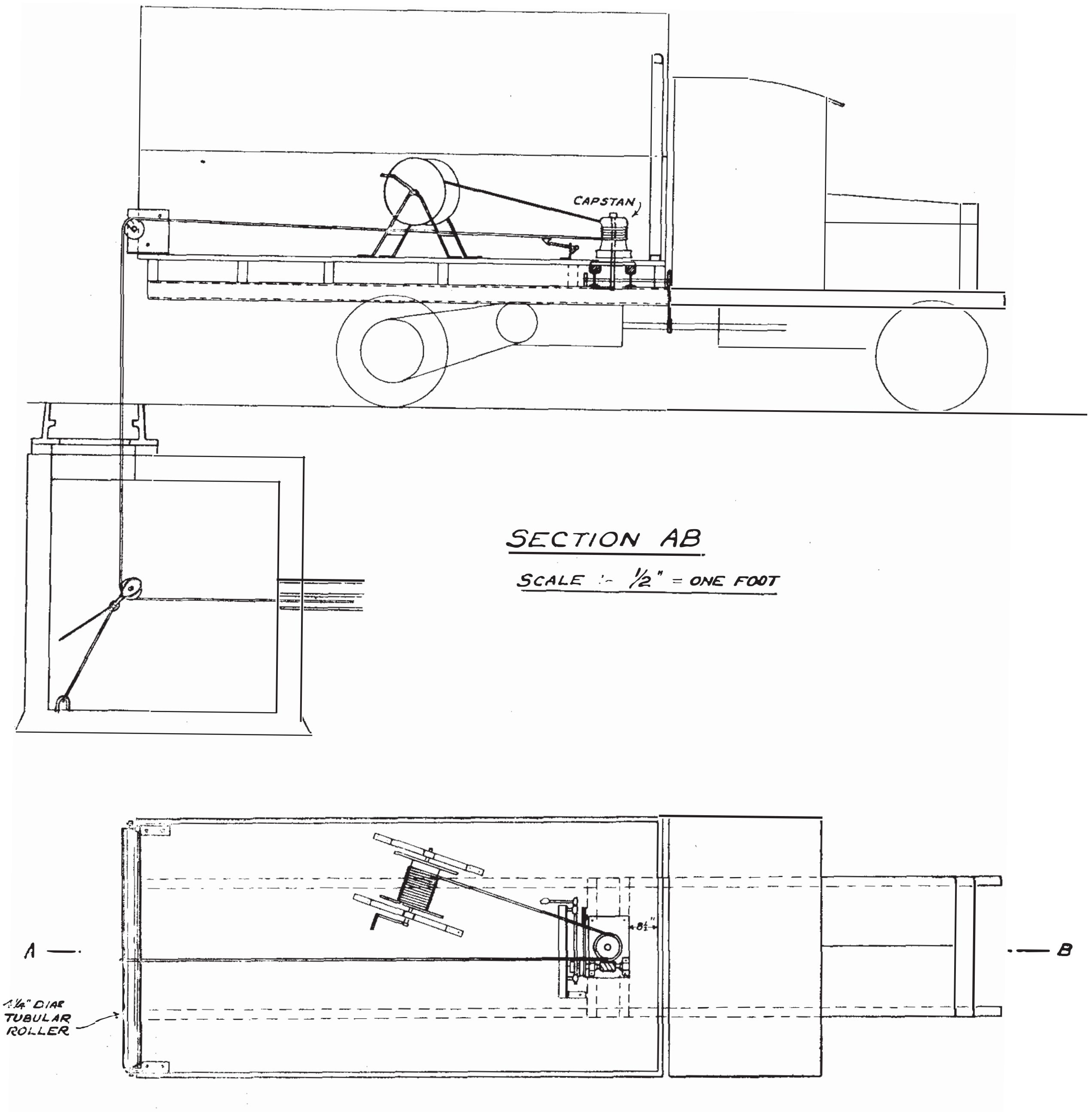


Fig. 7.—Chain driven Capstan as fitted to 3 ton Albion Lorry.

3 TON ALBION LORRY FITTED WITH CAPSTAN.

Schedule showing the Actual Costs associated with the gang using the 3 Ton Lorry as compared with the Standard Rates.

R. T. Hall's gang. Shedule B.

	Week Ending 26th October, 1928.		Week Ending 2nd November, 1928.		Week Ending 9th November, 1928.		Week Ending 16th November, 1928.	
Length of Section and Type of Cable ...	Yds. 97 200/6½ Gp.2 97 300/10 Gp.3 145 400/10 Gp.3 60 500/10 Gp.3 1719⅜ 800/6½ Gp.3 697 800/10 Gp.3		Yds. 109½ 300/6½ Gp.2 114 500/6½ Gp.3 263 600/6½ Gp.3 631½ 800/6½ Gp.3 331½ 1000/6½ Gp.3 528½ 800/10 Gp.3		Yds. 382 800/6½ Gp.3 251½ 400/10 Gp.3 191 800/10 Gp.3		Yds. 31 300/6½ Gp.2 192 400/6½ Gp.3 211 500/6½ Gp.3 31 800/6½ Gp.3 188 400/10 Gp.3 285 500/10 Gp.3 439 800/10 Gp.3	
	Actual M.Hrs.	Standard Rates.	Actual M.Hrs.	Standard Rates.	Actual M.Hrs.	Standard Rates.	Actual M.Hrs.	Standard Rates.
Effective Manhours:								
Cable drawn in ...	321	555	232	386	84	165	169	273
Ineffective Time ...	210	189	69	131	18	56	120	93
Total M.Hrs. ...	531	744	301	517	102	221	289	366
Cost at Average Rate of 1/3⅜=	£34 0 0	£48 0 0	£19 10 0	£33 0 0	£6 10 0	£14 0 0	£18 10 0	£23 10 0
Cost of 3 ton Lorry ...	£6 10 0		£7 10 0		£5 10 0		£7 0 0	
Estimated Cartage ...		£4 0 0		£5 0 0		£3 0 0		£5 0 0
Total Cost	40 10 0	£52 0 0	£27 0 0	£38 0 0	£12 0 0	£17 0 0	£25 10 0	£28 10 0
Net Saving ...	£11 10 0		£11 0 0		£5 0 0		£3 0 0	

The drums were delivered at the various manhole sites by the Railway Company and cartage on that account is not therefore taken into consideration. The net saving for the period under review amounted to £30 10s. 0d.

The rope used for drawing in the heavier types of cable is impregnated with oil for preservative purposes, and when stress is applied this oil exudes and becomes a source of trouble, in consequence of the convolutions on the capstan slipping even with the maximum number of turns wound on the bollard. The delay which ensues increases the cost of the work, this additional expense being out of all proportion to the comparatively small saving due to preservation of the rope. To obviate this drawback, steel hawsers of 1″ diameter are used, but care is taken, by frequent inspection of the strands, to see that needle ends are not formed. In order to avoid handling the hawsers in taking the turns from the bollard of the capstan a hand worked Hawser Winder is used, as shown in Fig. **8**. This arrangement dispenses with the operation of flaking or coiling the wire and forms a compact and tidy method of dealing with the hawser as it leaves the capstan.

Emptying of manholes. The clearing of water from manholes is often a source of expense, particularly if adequate facilities for pumping or bailing are not available. To provide means for rapid emptying of manholes, a pump designed and constructed in the local workshops is fixed

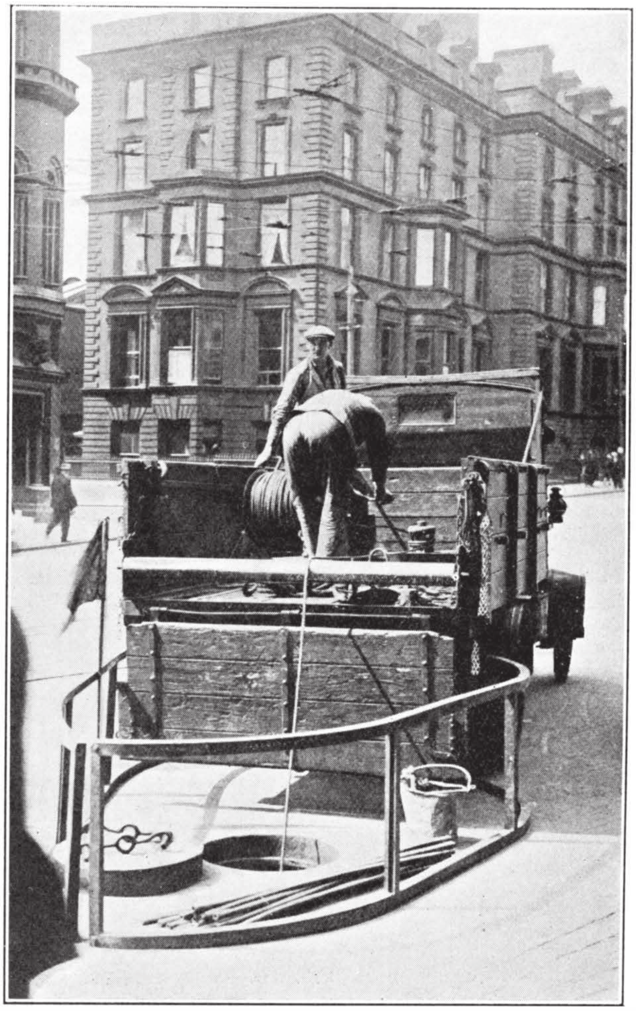


FIG. 8.—STEEL HAWSER AFTER LEAVING THE CAPSTAN BEING COILED ON HAWSER WINDER.

on the 3 ton lorry and is driven by the engine of the vehicle. This pump, which is of the plunger type, is capable of lifting 1,500 gallons of water per hour, and by its aid a manhole of average proportions filled with water can be emptied in less than two hours. The pump is shown in action in Fig. **9**, whilst details of its construction are shown in Fig. **10**. It consists of a cast iron cylinder of 3" bore securely mounted to the off-side member of the Albion lorry. Working in the cylinder is a 3" bronze piston coupled to an eccentric sheave which is fitted on the carden shaft of the lorry by means of a strap and a connecting rod giving a stroke of 3". A bronze head containing an inlet and an outlet port of 1" × ½" is mounted on the cylinder. Operating on these ports are two valves which enable a stream of water to be pumped, the suction being sufficient to permit water to be drawn from a depth of 20 ft. It will readily be understood that a pump of this description, working without intermission, enables a manhole to be cleared of water in less time than is the case with a hand worked pump. The cost of constructing and fitting a pump of this kind is about £12. The labour associated with bailing or with the work-

Fig. **9**.—Plunger Pump in operation.

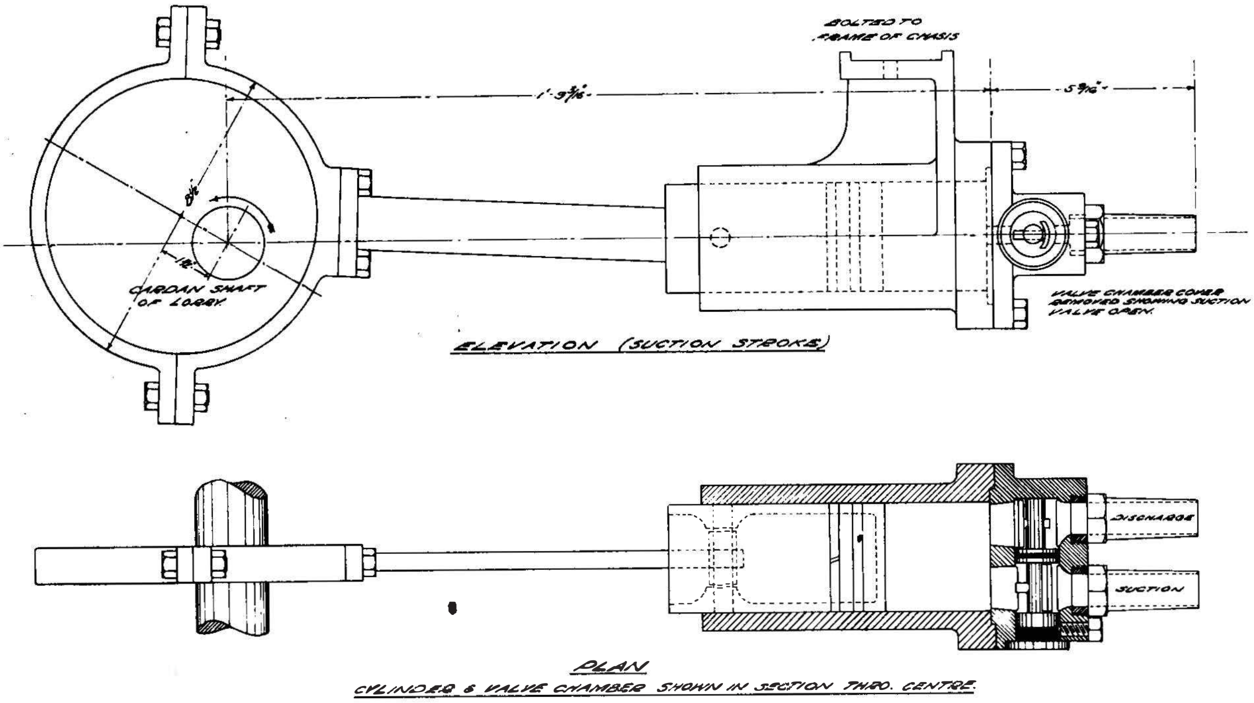

BOLTED TO FRAME OF CHASIS
1'·3 3/16"
5 9/16"
8½
1½
CARDAN SHAFT OF LORRY
VALVE CHAMBER COVER REMOVED SHOWING SUCTION VALVE OPEN
ELEVATION (SUCTION STROKE)
DISCHARGE
SUCTION
PLAN
CYLINDER & VALVE CHAMBER SHOWN IN SECTION THRO. CENTRE

Fig. **10**.—Motor driver Pump fitted to 3 ton Albion Lorry.

ing of a hand pump of any description requires great physical effort and when the quantity of water to be cleared is considerable, the operation becomes an arduous task. The amount of ineffective time which may be expended in the process is often a factor of some importance and the energy required to keep a hand pump in continuous operation has an exhausting effect on the men engaged.

The introduction of these mechanical aids were at first regarded with suspicion by the gangs who had to operate them, due no doubt to fear of fewer personnel being required, but after becoming more accustomed to their use workmen soon appreciated the extent to which they were relieved from the more laborious aspects of their work; and when Foremen found that their daily output was increased with less manual effort, the original antipathy disappeared and now the use of the appliances is regarded by gangs as an essential portion of their equipment.

[*The methods described in the foregoing article have been carried out in the Northern District, but it should be understood that they should not be regarded as the approved standard practice of the Department.—Editors, P.O.E.E. Journal.*]

DAMAGE TO POST OFFICE CABLES BY FIRES IN LONDON SUBWAYS.

THE London Engineering District has been particularly unfortunate of late, owing to the number of serious breakdowns of cables due to fire and explosion. Most readers of this Journal are aware of the innocuous nature of telephone cables and will not have been deceived by the misleading headlines in the newspapers, such as " Fire in Telephone Subway," " Another Telephone Fire," etc. Those who are unacquainted with the facts may, however, be led to imagine that telephone cables are a source of danger, and it may be of some interest to describe the damage that was done by the fires in the Victoria Embankment subway, the steps taken to restore service, and the verdict of the Coroner's jury, which, in accordance with the usual practice when fires occur in the City of London, sat to investigate the cause and to suggest preventive measures.

Probably not many persons are aware of the existence of a large system of subways under the streets of the Metropolis. From time to time a man may be seen descending with a safety lamp, but there is nothing to indicate that he is not entering a sewer or jointing chamber.

The subways referred to are not for the purpose of providing a safe walking place for pedestrians, but for the accommodation of pipes, cables and services of various undertakers. It is possible for a duly authorised person to walk from the Mansion House to Westminster Bridge, a distance of two miles, without coming to the surface.

In addition to the subway under Queen Victoria Street and the Victoria Embankment, there are pipe subways under Holborn Viaduct, St. Bride Street, Shaftesbury Avenue, Charing Cross Road, Kingsway, Commercial Road and other places. The total length of the subways is about seven miles. Most of the subways are owned by the London County Council and the remainder by the City of London Corporation.

The subways vary in size. The subway under the Victoria Embankment is 9 feet wide and 7′ 6″ high. Fig. 1 shows a typical section of this subway.

These subways are extended as opportunity occurs. When the large underground station was constructed under the open space opposite the Royal Exchange and Mansion House, a pipe subway was constructed underneath the station with laterals opposite the various thoroughfares which radiate therefrom. A similar subway has recently been constructed under the new station at Piccadilly Circus.

There is no doubt that the subways serve a useful purpose, and in fact are more useful than could possibly have been foreseen at the time when the scheme was originated. In those days horsed omnibus and hansom cabs were the usual modes of conveyance and much less travelling was done. Nevertheless, the necessity for reducing the interruptions to traffic due to pipe-laying operations was then held to be sufficient to justify the expense involved in the provision of pipe and cable subways.

The introduction of motor traffic has enormously increased the number of vehicles using the roads and a blockage due to road operations can now cause much greater dislocation than was the

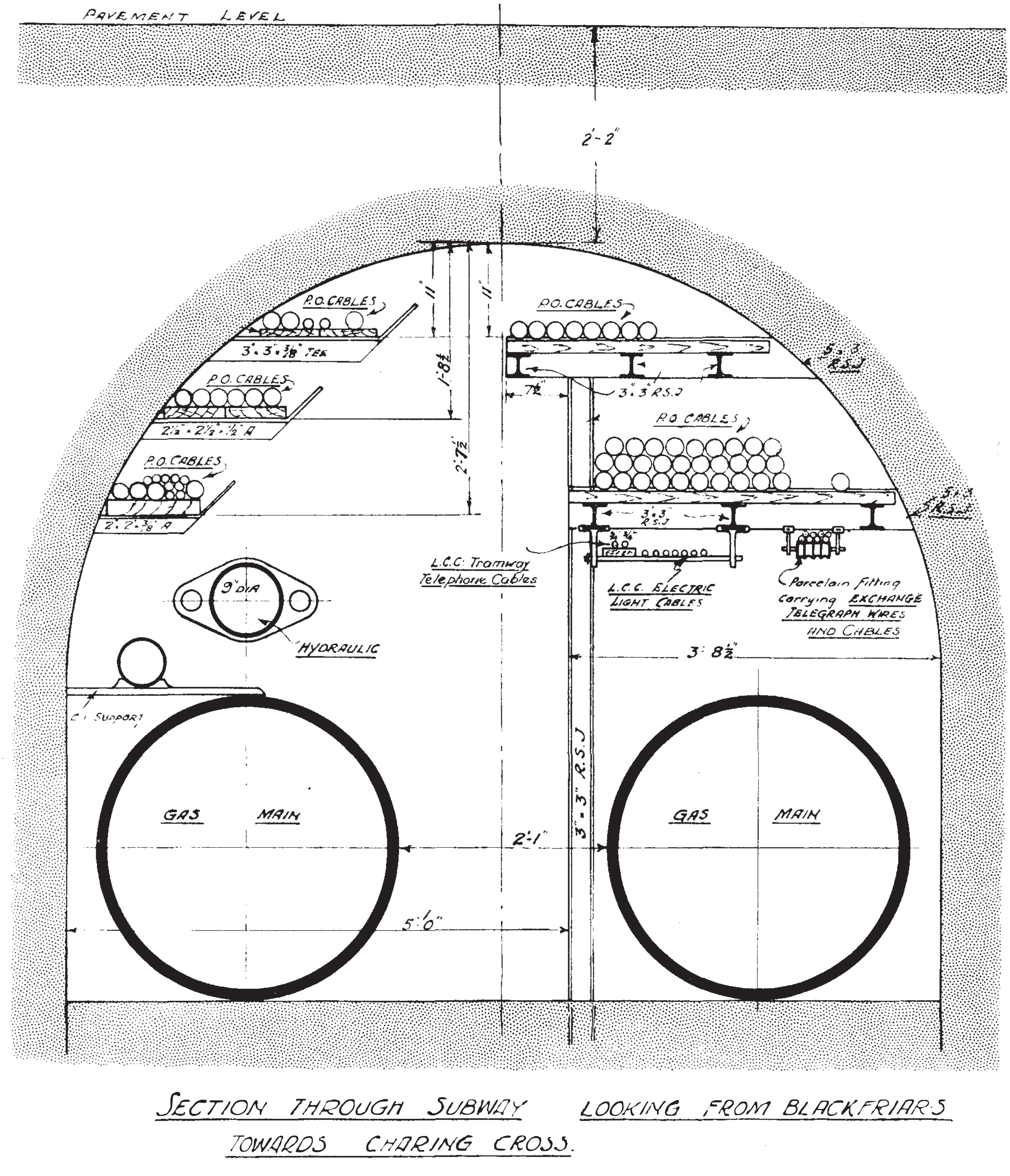


FIG. 1.—TYPICAL SECTION OF VICTORIA EMBANKMENT SUBWAY.

case in the days of horse traffic. Although there is inherent possibility of quick motion in a modern vehicle, the occurrence of a few street repair operations soon nullifies that advantage and makes it desirable to resort to walking, if a comparatively short distance only has to be covered. It is not surprising, therefore, that some authorities would like to have subways in every street and to forbid all street openings for the purposes of laying mains. Opinion is not unanimous upon this point. Apprehension is felt in some quarters about the existence in the same subway of high and low tension electric light mains, gas mains up to 36″ diameter, hydraulic mains carrying water compressed to 750 lbs. per square inch and telephone cables. All but the latter can cause interruption of the others if a failure occurs.

Until recently, however, there has been no trouble, although some of the subways have been in existence for over 50 years, and during almost the whole of that time the above types of plant have existed together in the same section of subway.

A contributory cause of the recent trouble was the great Thames flood which occurred on January, 1928, when the tide was abnormal, not only in its height, but in the measure that it exceeded the previous highest tide. Up to that time the highest tide previously recorded was in 1881, which exceeded the previous highest tide in 1875 by 3 inches, whereas the tide in January, 1928, exceeded that of 1881 by no less than 11 inches. Pepys refers to a flood which occurred in December, 1663, " 7th. Up betimes and it being a frosty morning walked on foot to White Hall. . . . At White Hall I hear and find that there was the last night the greatest tide that was ever remembered in England to have been in this river; all White Hall having been drowned, of which there was great discourse." It is recorded of a flood in 1791 that " boats came through the passage of Old Palace Yard from the Thames and round up to Westminster Hall Gate." Neither of these tides is reckoned to have exceeded 15 ft. 8 inches above ordnance datum, whereas in January, 1928, the tide was 18 feet 6 inches above ordnance datum.

In contrast to these floods it may be mentioned that in 1717 the river fell so low that persons are said to have walked across it.

It will be remembered that in January, 1928, the basements of many houses were flooded and several persons were drowned. The water entered the Thames Embankment subway and most of the plant was submerged. The huge gas mains floated and the joints drew, causing a serious leakage of gas; water penetrated a number of telephone cables, and some cables which were used by the London County Council to supply light to the Victoria Embankment were badly damaged. Repairs were put in hand by the various undertakers. Some of these repairs were effected in a temporary manner and the permanent repairs and replacements, which can only be carried out in short sections, are now being executed.

The first intimation of further trouble in the subway was received shortly after 8.30 p.m. on Saturday, September 8th, 1928, when it was reported that a number of junctions to certain exchanges were out of order. This was quickly followed by an intimation that all communication between certain exchanges had ceased. A rapid mental review of the exchanges affected indicated that there was only one section of route where circuits to all these exchanges could be interrupted at the same time, and this was on the Victoria Embankment. This inference was confirmed by a subsequent report that a fire was raging in the subway.

A visit was made to the spot, but, although the flames had been subdued, the heat was so intense and the danger so great that the fire brigade officials would not permit anyone but firemen equipped with special apparatus to descend. When permission was ultimately given, it was found that over sixty telephone, telegraph and electric light cables had been completely destroyed for a distance of about 60 yards. Some tons of melted lead from the sheaths were lying on the racks and ground. Molten lead had also got between the conductors and had welded the cables into a solid mass. Figs. **2** and **3** will show the state of the subway. Cables can be seen with all the lead sheath burnt off.

It was evident that the restoration of circuits in the subway would be very difficult as the masses of metal, which had formerly been cables, would have to be sawn away in sections. As soon as advice was received that the breakdown was serious, the emergency officer at the Controller of Stores had been advised by telephone that demands would be made for lengths of cable and a broad indication was given of the types of cable that would probably be required. This officer promptly called out his special staff with vehicles, and by the time that a survey of the damage had been made, he was ready to commence loading. The cables were ordered forward and a plan of operations prepared.

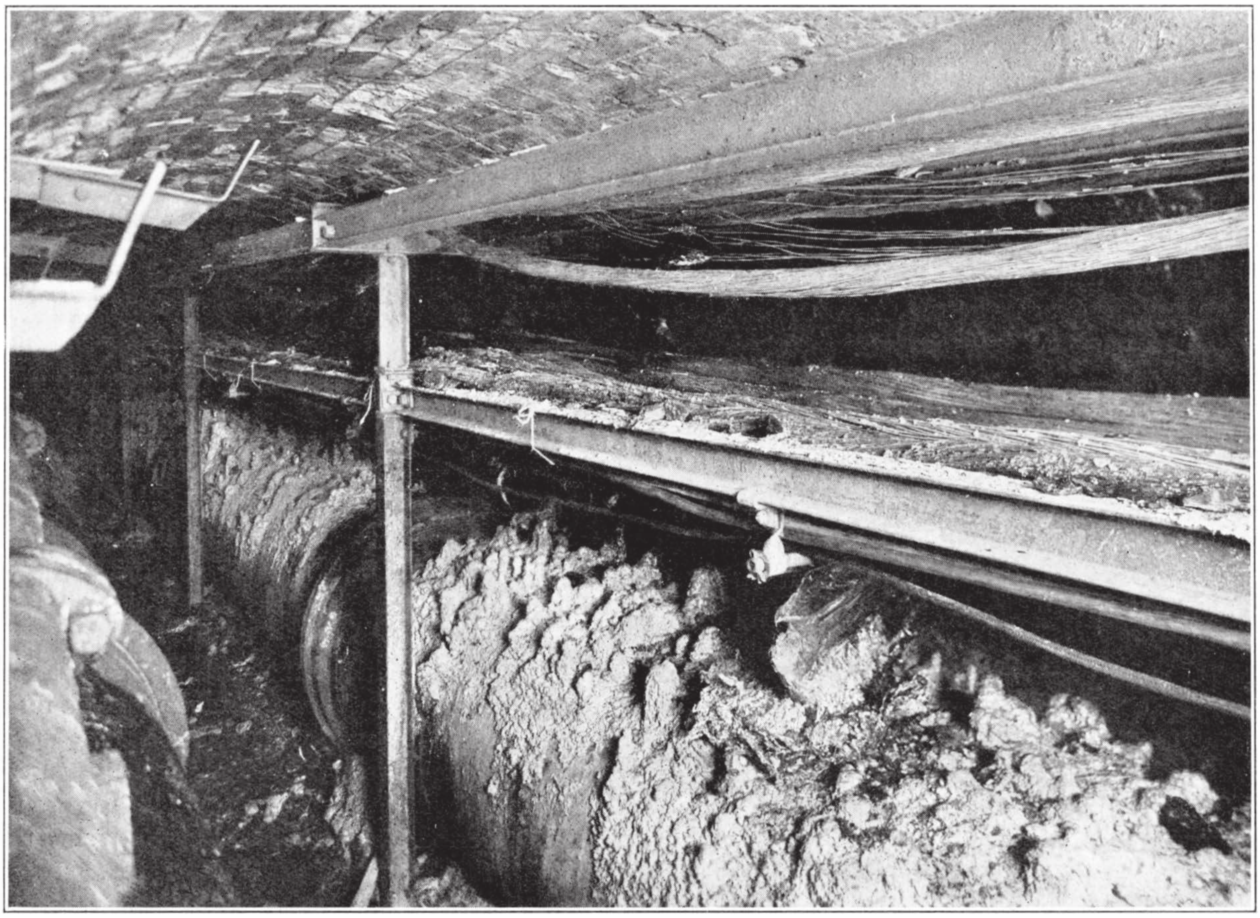


Fig. 2.—Victoria Embankment Subway. Damage caused to Cables in September, 1928, Fire.

Examination of the records showed that the 46 telephone and telegraph cables destroyed carried 2,872 working junctions to 43 London exchanges, 130 Trunks to Provincial towns and foreign countries, 85 telegraph circuits and 1,500 subscribers exchange lines. In addition, a large number of private wires, power leads, ringing leads, etc., were affected. Steps were at once taken to divert as many circuits as possible to alternative routes. By Monday, the 10th of that month, 79 trunk and 750 junction circuits had been provided by alternative routes. Progress after this was somewhat slower, owing to the fact that in many cases double, triple and even quadruple changes had to be made in order to free a circuit between the desired points. The alternative routes were in some cases very circuitous and the speech efficiency was necessarily reduced, but speech could be obtained and this was better than nothing. Altogether about 1600 circuits were provided by alternative routes. Arrangements were also made to provide additional circuits at certain exchanges which were being used as lending junction centres by other exchanges. The work involved in providing alternative circuits can perhaps be gauged by the fact that over 4000 diversions were carried out on the exchange distributing frames, apart from those effected in jointing chambers. By the end of the week the number of circuits out of order had been reduced to 850. Owing to the provision of additional circuits on existing routes, the careful consideration given to the order of restoration and the diversion of telephone traffic, it was possible by this time to provide a service which was almost normal.

While the provision of alternative routes was being effected, the damaged cables were being withdrawn, the subway reconditioned and new cables drawn in and jointed. Each undertaker was, of course, anxious to get plant restored, and owing to the limited space available there was much congestion, but with mutual goodwill and co-operation it was possible to make good progress. As each junction cable was restored, the circuits which had been diverted to circuitous routes were transferred to the direct cable. The whole of the destroyed cables were replaced and brought into use within a month of the disaster. Fig. **4** shows the repair work in hand.

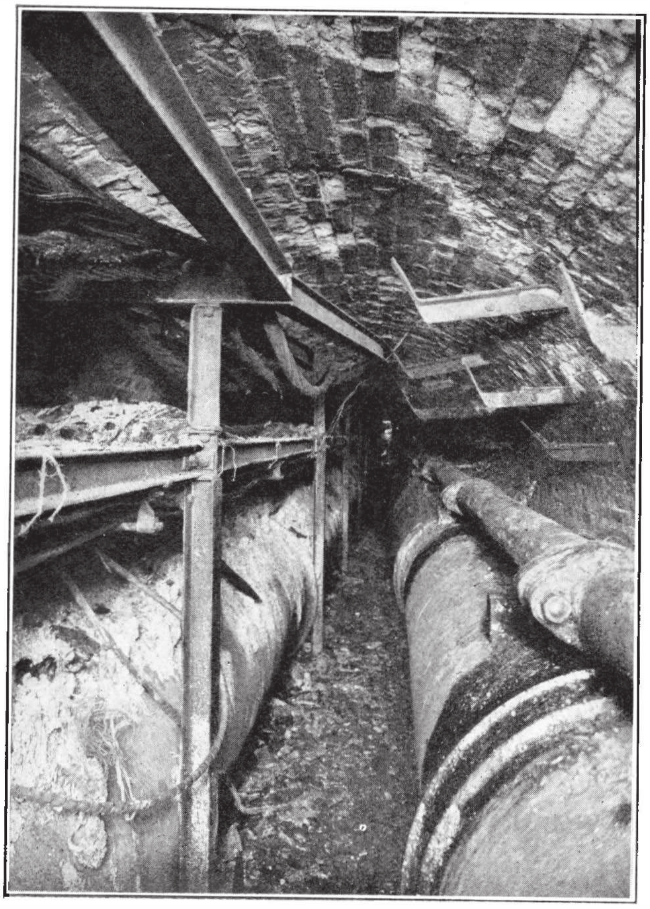


Fig. **3**.—September, 1928, Fire. Another view of the damage.

The finding of the jury was that the fire was due to a defective cut-out box on the L.C.C. lighting cable, which had been damaged by the floods previously referred to, and it was recommended that the whole lighting system should be replaced by a modern method. This recommendation was accepted by the London County Council and a scheme was prepared for making the Embankment one of the finest lighted thoroughfares in the world.

Before the new scheme was completed, a further serious fire occurred in the Victoria Embankment subway at 9.35 p.m. on June 6th, not many yards from the scene of the previous fire. Owing to the prompt action of the Fire Brigade the fire was subdued before it had spread so far as on the previous occasion, but, nevertheless, much dislocation was temporarily caused to the telephone service. Twenty large cables containing junction and subscribers' circuits were completely destroyed and also a number of small cables containing private wires and miscellaneous circuits. Altogether about 3300 working circuits were affected, of which 985 were subscribers' lines. The method of restoration was similar to that adopted on the previous occasion, and by Tuesday, the 11th June, all the subscribers' lines had been restored and the number of other faulty circuits reduced to 540. As 300 additional circuits had been provided to junction lending circuits and the plan of restoration included deferment until the last of the least important circuits, the Controller, L.T.S., was able to report on the 12th June that a satisfactory service was being given on all routes. All the cables were replaced by June 18th and the diverted circuits were then restored to their original route.

A further enquiry was held by the City coroner and a jury. The verdict was that the fire was occasioned by sparking at a defective porcelain connector on the L.C.C. lighting cables. The cables which were held by the Coroner and jury to have been the cause of the fire on each occasion have now been thrown out of use.

Between the periods of the above fire there occurred a gas explosion in Holborn, which resulted in the complete wreckage of a Post Office tube containing telephone cables only. In this case not only was great damage caused to the telephone cables in the tube and the plant of other undertakers under the road, but considerable damage was also caused to private property. Much prominence has been given to this matter, and it is not proposed to describe the method of restoration, which was similar in principle to those already mentioned. Neither can full information be given as to the actual steps taken to provide alternative routes. It must suffice to say that duct routes were linked up by short lengths of conduit, manholes were enlarged to embrace adjacent pipe routes and cables were linked up at points, some of which were three miles away from the scenes of the breakdown so as to make it possible to make the fullest use of all spare circuits available. Alterations were made at a number of exchanges so as to permit of junctions being worked in tandem and the limited number of circuits on the gradings at automatic exchanges were rearranged so that the greatest availability could be secured.

A number of smaller disasters have also occurred due to explosions, water main bursts and road subsidences, and in some cases the telephone plant has been affected. The fact of the matter is that the telephone system in London has grown to such an extent that there are very few streets of any importance that do not contain telephone conduits and cables, so that when any serious damage occurs to a road there is almost sure to be some telephone plant in the vicinity which is liable to be injured. Telephone cables and conduits are sufficiently robust to withstand any ordinary disturbance, but explosions, fires

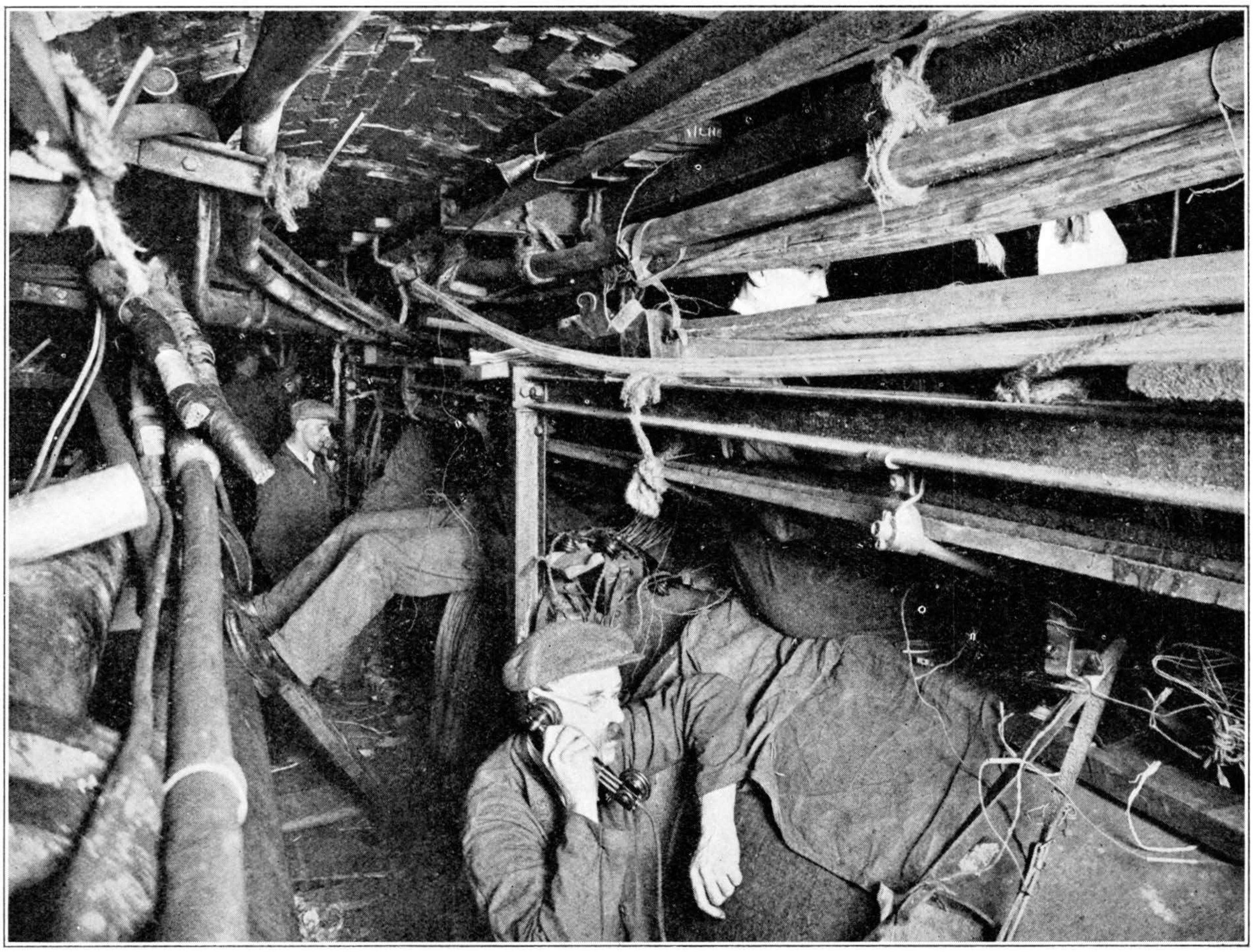


Fig. 4.—Victoria Embankment, September, 1928, Fire. Repair work in progress.

and pneumatic drills are in a different category, and it would not be practicable to provide plant which would be quite immune from injury by these agencies.

So far as is practicable the junctions which connect exchanges are divided between alternative routes and the extent of the possible dislocation of traffic due to breakdown thus reduced. There are many cases, however, in which alternative routes cannot be provided. Cable ducts must follow the roads and there may not be an alternative route, or, if it exists, it may be so circuitous that not only would the cost be prohibitive but its adoption would involve a serious degradation of efficiency.

It is only natural that as the brunt of the restoration work falls upon the engineer he should give great attention to the matters of avoiding breakdowns and limiting dislocation of traffic. No simple rules can be laid down and each case must be considered on its merits. Careful selection of routes, close supervision of construction work and a good organisation for dealing with emergencies are, of course, essential.

J.G.H.

SUBSIDENCE OF IMPORTANT CABLE ROUTES: BOUGHTON HILL, NEAR CANTERBURY.

FOLLOWING the very bad weather conditions of the winter of 1927-8, a subsidence occurred in the embankment at the foot of Boughton Hill, near Canterbury.

A two-way duct carrying two very important cables was involved. The cables were (1) a recent 160 pr/40 PCMT. L. and B. cable, serving the Canterbury Repeater Station, and thence the Continent; (2) an older cable PC. 8 pr/150 MT + 24 pr/100 MT + 42 pr/70 MT + 5 pr/40 T, feeding chiefly the East Kent areas and also partly in use for Continental circuits. A loading coil manhole existed in the area of the subsidence.

Examination of the duct line showed that the ducts had been considerably displaced. Although only about 20 yds. of duct were involved, a downward displacement of 5 ft. and an outward displacement of 2ft. 6in. had taken place. Trial holes showed all ducts broken at the sockets, whilst the cable (1) mentioned above had pulled over the loading coil stubs in the manhole, and cable (2)—which was straight through in the manhole—had moved several inches. A joint about 130 yds. down the hill from the manhole also showed several inches movement up the hill, whilst a joint 200 yds. distance up the hill showed a similar displacement of the cable down the hill. At a joint 30 yds. from the manhole cable (2) was found to be pushing its sleeve into the duct.

The subsoil in the area of the subsidence is largely a mixture of sand and clay saturated with water.

Attempts to lift the duct and cable had to be abandoned, due to the risk of the embankment, and with it, the road giving way. The road is the important main London-Dover road (Watling Street).

The necessity for keeping the cables intact, however, was also of great importance. Cable (2) had already split its sheath close to the manhole and a wiped patch inserted. (Fortunately this defect was found in good time, as water was dripping on the sheath barely an inch away). Although cable (1) had not broken down, it was in a precarious condition, and it was decided at short notice to erect a 100 pr/10 cable on an existing trunk route for 300 yds. to clear the area of the subsidence and its possible extensions. 40 prs. were left in a normal condition through the L.C. manhole and 100 prs. were diverted to the small gauge aerial cable, thus missing the manhole.

Cable (2) was also wholly diverted to a similar length of the same class of cable. Cable (2) was not loaded at the manhole.

The Road Authorities took the subsidence in

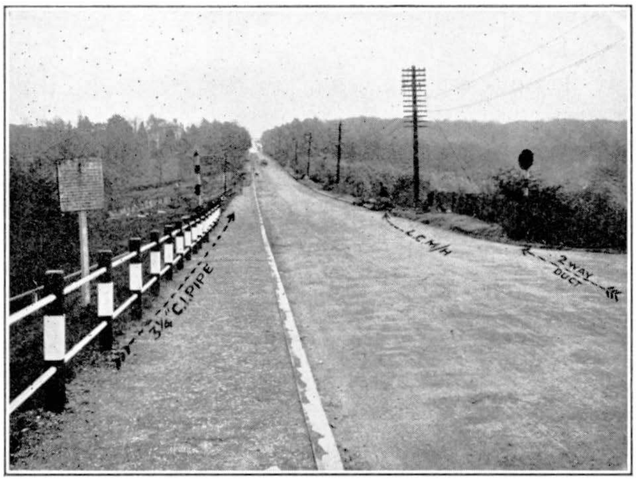


FIG. 1.—GENERAL VIEW OF BOUGHTON HILL.

hand and inserted a ferro-concrete kerb 3 feet deep, 18in. thick at the bottom, tapering to 6in. at the top. Drainage was also effected and the embankment remade.

The stability of the underground cables have been watched since the latter work was done and movements of the cables have been continuously recorded.

The aerial cables (ordinary underground types) have had a trying experience including a hurricane and extremely unusual variations of temperature, but fortunately no trouble has been experienced. The same remarks do not, however, apply to cable (1) in which two of the L.C. stub sheaths have split under strain but have been made good by local efforts without withdrawing the pots. Fortunately, by watching the manhole the defects came to light early enough to admit of repairs being effected before the breakdown stage.

The rapid growth of Continental services combined with the unsatisfactory transmission conditions set up by the aerial cables have latterly made urgent the necessity of restoring the original cables.

The subsoil conditions do not permit deep trenching and necessitated the abandonment of ducts and cables in the area of the subsidence. The ducts were replaced by 2-3¼in. steel pipes laid shallow close to the kerb, and securely concreted to the latter, from the manhole for a distance of 80 yards up the hill. A ferro-concrete jointing box constructed at this latter point embraces both ducts and steel pipes. The concreted pipe gives additional strength to the kerb and any future subsidence affecting the cables in this length will be visible. New cables of similar type to the old were drawn into the steel pipes.

The question of interference with the important Continental services during the diversion work arose, and instructions were given to carry out the diversions over the Whitsun holiday period. The repair work was rather complicated.

Cable (1) was split into 5 stubs at the L.C. manhole. All stubs were much displaced and, in addition, Cable (2) pressed hard against them under heavy strain. 40 pairs of cable (1) were working through the manhole and the remaining 100 pairs in the aerial cable. A balanced joint also existed 30 yds. from the manhole under the new pipe line and in the abandoned length. In addition, it was demanded that no disturbance must arise on working circuits.

The scheme adopted was as follows:—

(1) A speaker circuit was provided between the scene of operations and Canterbury Repeater Station.

(2) It was decided to save the L.C. Stub connecting cables. This necessitated making a joint close to the pothead in a very difficult position. It was also decided not to rebalance the section.

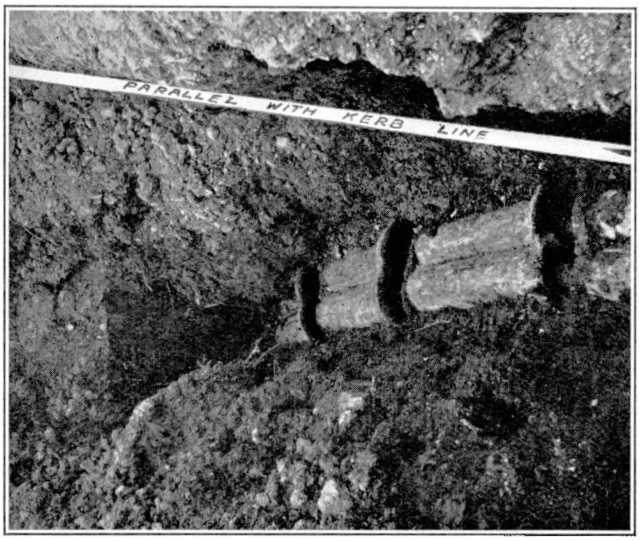


FIG. 2.—BOUGHTON HILL. STATE OF DUCTS ABOUT 20 YARDS FROM MANHOLE.

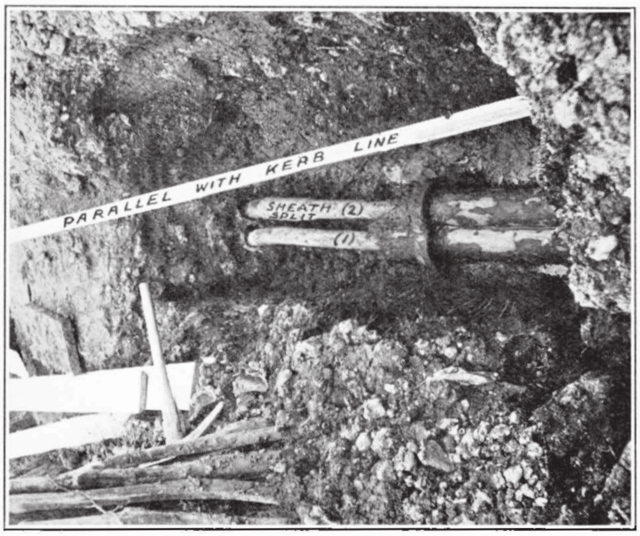


Fig. 3.—Boughton Hill. Ducts next to Manhole at bottom of Hill.

(3) The cable pairs were divided into groups to suit working conditions. Unfortunately, these groups did not correspond with loading coil stubs nor with the normal order of jointing in a cable of this type. The circuits working in a group were temporarily transferred to other groups. The wires thrown spare were tapped out and numbered at the Canterbury end of the faulty section and connected to corresponding pairs in the new section of cable, but at the L.C. manhole crosses had to be made equivalent to those existing in the standard joint cut out. This complicated matters considerably.

(4) On completion of one group the working circuits were transferred and successive groups dealt with in a similar manner. Close co-operation between the London Trunk Exchange and Canterbury Repeater Station and the staff at Boughton Hill was maintained throughout and each circuit transferred to the repaired cable was thoroughly tested by London before acceptance. The fact that the work was carried out without a hitch and without causing a single interruption on a working circuit reflects the greatest credit to the staff employed on the work.

Cable (2) was dealt with in a more simple manner. The new length of cable was joined into the existing cable at each end of the new pipe line under the usual M.T. jointing conditions. The lengths thus jointed were numbered out at each of the aerial cable ends. Diversions were effected at the latter points in conjunction with Canterbury Repeater Station.

The abandoned cables from the manhole to the first joint 30 yds. away have been securely clamped at each end by special fittings to retain the strains taken before the diversions to the new cables, so as to reduce the risk of any further subsidence due to the removal of any support given by the cable.

The photographs show a general view of the hill, the condition of the subsided duct line and a distorted kerb further up the hill on the opposite side. On this side of the hill it will be necessary to make good, eventually, a composite cable, which is at present interrupted by an overhead cable. In this case a 3¼in. C.I. pipe is involved. A number of subsidences have taken place on this side of the hill in recent years, and the exact position and condition of the pipe have yet to be determined.

H.R.J.D.

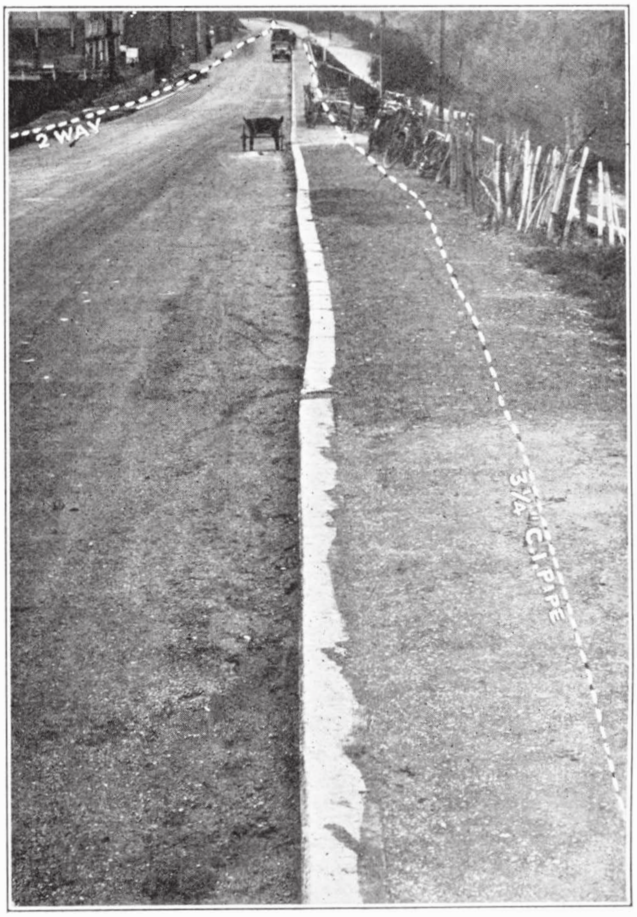
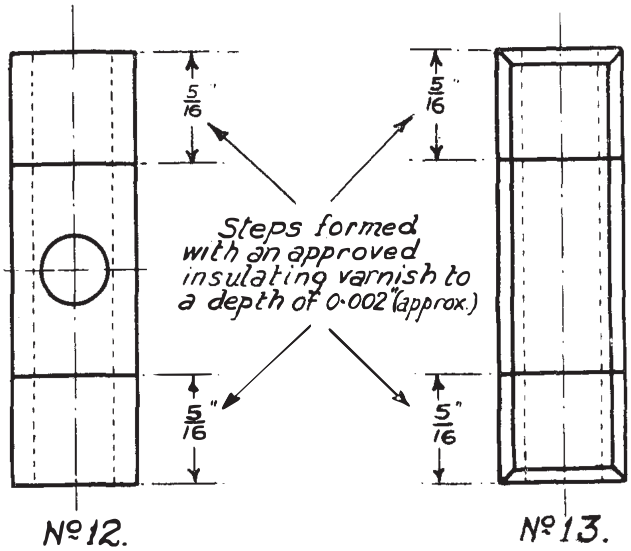


Fig. 4.—Boughton Hill. View showing distortion of Kerb Line.

AN IMPROVED LIGHTNING PROTECTOR.

THE standard carbon lightning protector, consisting of two grooved rectangular carbon blocks with a mica separator, so extensively used on telephone circuits, has proved in service a very efficient unit in protecting the apparatus from damage but it has several very troublesome defects. Unless the spring clips grip the protector, the mica has a tendency to slip, resulting in a contact between the line and earth carbons. The line carbon has a recess 2 to 3 mils deep ground out of the carbon block, which has the effect of removing the hard natural skin on the carbon, leaving a more or less loose surface which is readily disintegrated by line discharges during thundery weather and resulting in intermittent earths and loss of insulation.


5/16"
5/16"
Steps formed with an approved insulating varnish to a depth of 0·002" (approx.)
5/16"
5/16"
№12.
№13.

THE NEW TWO-UNIT PROTECTOR.

The faults due to these defects are easily remedied at the exchange end, but in the case of out stations considerable travelling time is incurred.

The grinding of so small an amount as 2 to 3 mils in the line carbon is a difficult operation and in consequence the manufacturing tolerances have had to be increased, thereby reducing the efficiency of the protector.

The necessity for removing the defects mentioned above has received attention for some time, but as the number of protectors of this type in use runs into millions, it was essential that any new type should be subjected to exhaustive test and prolonged trial in service before adoption.

A new two-unit protector, interchangeable with the three-unit protector, has been devised which overcomes the objections detailed and has been standardised by the Department. The two carbon units will be known as Carbons, Protector, No. 12 (a plain carbon) and No. 13 (a chamfered carbon).

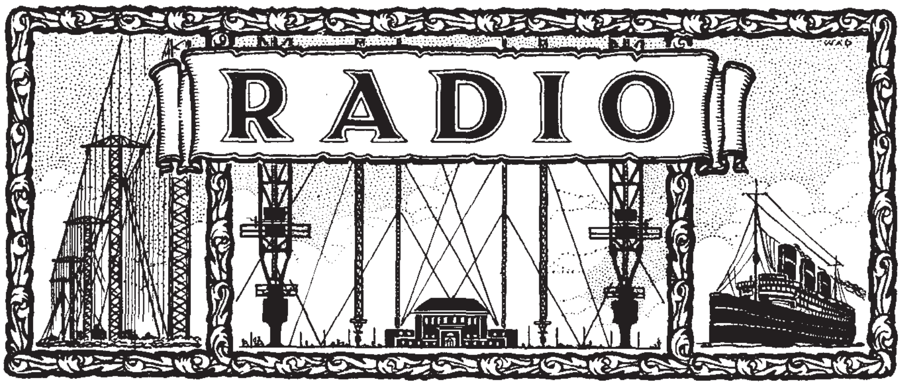
In the new protector the active surfaces of both carbons are flat and are first sprayed with a varnish of collodion base containing sufficient fusible gum to cause fusion on sparking, but the amount is not sufficient to affect the puncturing voltage. The effect of this coating is to make the active surface self-sealing, preventing or at any rate sealing any disintegrated carbon dust produced in the manufacture.

Instead of a mica separator, the portion of the active surfaces of the carbon blocks are coated at each end with a thin layer of varnish of a cellulose acetate base possessing a high electrical insulation when dry. The varnish dries nail-hard and is non-hygroscopic. The two blocks are tested to discharge at 500 to 750 volts D.C. and must test " Infinity " with a 250 volt D.C. megger. The varnish must show no indication of softening or sticking after heating to a temperature of 212°F. for one hour. It will be seen that the number of units has been reduced from three to two and the efficiency of the protector increased.

The protector has received a thorough trial in the British Islands, and favourable reports have been received from the Telephone Authorities of a number of tropical countries, particularly where severe thunderstorms are experienced in combination with very humid atmospheric conditions.

The new potector was devised by the P.O. Engineering Department and has been developed on a manufacturing basis by Messrs. Ericsson Telephones, Ltd., Beeston, Notts.

F. McC.



ALLOCATION OF WAVE BANDS ACCORDING TO WASHINGTON CONVENTION.

Frequencies in Kilocycles per second (Kc/s)	Approximate wavelengths in metres.	Services.
10—100	30,000—3,000	Fixed services.
100—110	3,000—2,725	Fixed services and mobile services.
110—125	2,725—2,400	Mobile services.
125—150[1]	2,400—2,000[1]	Maritime mobile services open to public correspondence exclusively.
150—160	2,000—1,875	Mobile services.
160—194	1,875—1,550	(*a*) Broadcasting. (*b*) Fixed services. (*c*) Mobile services. The conditions for use of this band are subject to the following regional arrangements:— All regions where broadcasting stations now exist working on frequencies below 300 Kc/s (above 1,000 m.) Broadcasting Other regions Fixed services. Mobile services. Regional arrangements will respect the rights of other regions in this band.
194—285	1,550—1050	(*a*) Mobile services. (*b*) Fixed services. (*c*) Broadcasting. The conditions for use of this band are subject to the following regional arrangements:— Europe (*a*) Air mobile services exclusively. (*b*) Air fixed services exclusively. (*c*) Within the band 250-285 Kc/s (1200-1050 m). Fixed services not open to public correspondence (*d*) Broadcasting within the band 194-224 Kc/s (1550-1340 m).
1,550—1050	194—285	Other regions (*a*) Mobile services except commercial ship stations. (*b*) Air fixed services exclusively. (*c*) Fixed services not open to public correpondence.
285—315	1,050—950	Radiobeacons.
315—350[2]	950—850[2]	Air services exclusively.
350—360	850—830	Mobile services not open to public correspondence.
360—390	830—770	(*a*) Direction Finding. (*b*) Mobile services on condition that they do not interfere with direction finding.
390—460	770—650	Mobile services.
460—485	650—620	Mobile services (except damped waves and radio telephony).
485—515[3]	620—580[3]	Mobile services (distress, calling, etc.).
515—550	580—545	Mobile services not open to public correspondence (except damped waves and radio telephony).
550—1,300[4]	545—230[4]	Broadcasting.
1,300—1,500	230—200	(*a*) Broadcasting. (*b*) Maritime mobile services, wave of 1,365 Kc/s (220 m.) exclusively
1,500—1,715	200—175	Mobile services.
1,715—2,000	175—150	Mobile services. Fixed services. Amateurs.
2,000—2,250	150—133	Mobile services and fixed services.
2,250—2,750	133—109	Mobile services.
2,750—2,850	109—105	Fixed services.
2,850—3,500	105—85	Mobile services and fixed services.

Frequencies in Kilocycles per second (Kc/s)	Approximate wavelengths in metres.	Services.
3,500—4,000	85—75	Mobile services. Fixed services. Amateurs.
4,000—5,500	75—54	Mobile services and fixed services.
5,500—5,700	54—52·7	Mobile services.
5,700—6,000	52·7—50	Fixed services.
6,000—6,150	50—48.8	Broadcasting.
6,150—6,675	48.8—45	Mobile services.
6,675—7,000	45—42.8	Fixed services.
7,000—7,300	42.8—41	Amateurs.
7,300—8,200	41—36.6	Fixed services.
8,200—8,550	36.6—35·1	Mobile services.
8,550—8,900	35·1—33·7	Mobile services and fixed services.
8,900—9,500	33·7—31.6	Fixed services.
9,500—9,600	31.6—31.2	Broadcasting.
9,600—11,000	31.2—27·3	Fixed services.
11,000—11,400	27·3—26.3	Mobile services.
11,400—11,700	26.3—25.6	Fixed services.
11,700—11,900	25.6—25.2	Broadcasting.
11,900—12,300	25.2—24.4	Fixed services.
12,300—12,825	24·4—23·4	Mobile services.
12,825—13,350	23·4—22·4	Mobile services and fixed services.
13,350—14,000	22.4—21.4	Fixed services.
14,000—14,400	21.4—20.8	Amateurs.
14,400—15,100	20.8—19.85	Fixed services.
15,100—15,350	19·85—19·55	Broadcasting.
15,350—16,400	19·55—18.3	Fixed services.
16,400—17,100	18.3—17·5	Mobile services.
17,100—17,750	17·5—16.9	Mobile services and fixed services.
17,750—17,800	16.9—16.85	Broadcasting.
17,800—21,450	16.85—14	Fixed services.
21,450—21,550	14—13.9	Broadcasting.
21,550—22,300	13.9—13·45	Mobile services.
22,300—23,000	13·45—13·1	Mobile services and fixed services.
23,000—28,000	13.1—10.7	Not reserved.
28,000—30,000	10.7—10	Amateurs & experiments.
30,000—56,000	10 —5·35	Not reserved.
56,000—60,000	5·35—5	Amateurs & experiments.
Above 60,000	Below 5	Not reserved.

[1] The wave of 143 Kc/s (2,100 m.) is the calling wave for mobile stations using long continuous waves.

[2] The wave of 333 Kc/s (900 m.) is the international calling wave for air services.

[3] The wave of 500 Kc/s (600 m.) is the international calling and distress wave. It may be used for other purposes on condition that such use does not interfere with calls and distress signals.

[4] Mobile services may use the band 550 to 1,300 Kc/s (545-230 m.) on condition that such use does not interfere with the services of a country which uses this band exclusively for broadcasting.

Note.—It is recognised that short waves (frequencies from 6,000 to 23,000 Kc/s approximately—wavelengths from 50 to 13 m. approximately) are very efficient for long distance communications. It is recommended that as a general rule this band of waves should be reserved for that purpose in services between fixed points.

WIRELESS ECHOES OF LONG DELAY.

A. J. Gill, B.Sc., M.I.E.E., M.I.R.E.

SOME of the most interesting phenomena in connexion with the propagation of short-wave radio signals are the echo effects. These are of two distinct kinds, the first of which may be termed normal echoes and the second "long delay" echoes. The first or normal echoes are due to the passage of the wave round the world one or more times, and have usually been observed with stations using directional transmission. As a result the reception of a signal by a receiving station is followed by the reception of a number of more or less weaker signals at definite time intervals after the main signal. If the transmission conditions are suitable, these echo signals may be sufficiently powerful to interfere with reception and cause jamming. Sometimes, conditions are favourable for transmission round the world in both directions along the great circle containing the transmitting and receiving stations. In these circumstances two series of echoes can occur, one series propagated in one direction round the world and the other series in the opposite direction. If we call the time of transmission between the transmitting station and the receiving station t_1 by the shortest normal path, and t_2 by the opposite path, then $t_1 + t_2$ will be the time of transmission round the world and will be about 1/7 second. The main signal will then be received in a time t_1 by the positive direction, while the first echo will appear at a time t_2 by the negative direction. A second echo will appear in a time $2t_1 + t_2$ in the positive direction, while a third echo will appear in a time $t_1 + 2t_2$ in the negative direction, and so on.

The production of one or more of these echoes has been reported at different times by a number of observers and their appearance is explained by the favourable conditions for transmission at the time of their appearance.

The second class of echo, the long delay type, is of much rarer occurrence and up to the present has only been observed from the omnidirectional Dutch Station P.C.J.J. (Hilversum) working on 31.4 metres. These echoes appear several seconds, and sometimes minutes after the main or direct signal.

They were observed first in September, 1927, by Mr. Jorgen Hals at Oslo. Hals observed a normal echo at 1/7 sec. after the signal and an abnormal echo of about 1/10th or 1/20th the strength of the other at a time interval of about 3 seconds. Later, these echoes were observed simultaneously at Oslo and at two stations at Eindhoven, Holland. The echoes then appeared at time intervals of as much as 30 seconds after the signal.

In February, 1929, Mr. Hals observed echoes having a retardation of as much as 4 minutes 20 seconds; this corresponds to a transmission path of 52,000,000 miles.

Various explanations have been offered as to the cause of these echoes. Some, as for example, Störmer, Pedersen, and Wagner assume the echoes to be due to the waves being reflected from or propagated along bands of electrons distributed in the interplanetary space. Others, for example, Van de Pol, Appleton and Von Ardenne have suggested that the echoes may be due to particular conditions existing along the paths of the rays in or bounded by the ionised part of the earth's atmosphere.

Ardenne suggests that the rays travel round the world a large number of times at the normal velocity before descending. This involves the assumption that the attenuation of their path is almost zero. Appleton and Van der Pol on the other hand suggest that the delay may be due to the group velocities of the waves being very small under certain conditions of ionisation of the medium.

Dr. P. O. Pedersen has now written in English a monograph on the subject of these echoes in which he examines mathematically the possibility of the echoes being due to slow rate of propagation in the vicinity of the earth.* He shows that radio waves are propagated in an atmosphere consisting solely of electrons, without suffering any loss, but that such an atmosphere could not exist without the presence of positive ions. In these circumstances, the radio waves in consequence of the collisions between the electrons and the necessarily existing positive ions would be so greatly attenuated that the long delay echoes cannot have travelled a considerable part of the time in such an atmosphere. He then examines the possibility of the waves being reflected from ionised bands out in space. He shows that waves longer than 70 metres can neither penetrate out into space nor from outside penetrate the upper ionised layer and come down to earth. He also shows that the most favourable wave-length for such penetration will be somewhere about 30 metres.

His final conclusions are that:—

(1) Echoes delayed more than 10 seconds cannot be due to propagation entirely within the earth's atmosphere nor outside this in a medium so densely crowded with electrons that the group velocity of the waves is decreased to small values.

(2) Echoes delayed up to 30 or 60 seconds are probably due to propagation along or reflections from "Störmer" bands of electrons within the magnetic field of the earth.

(3) Occasionally echoes may be obtained with such great delay that those bands of ions to which the echoes are due must be located at such great distances from the earth (more than, for example, 25,000,000 miles) that they are outside the space in which the magnetic field of the earth exerts any appreciable direct influence.

Dr. Pedersen's work is of great interest and importance on the subject of these long delay echoes and should be consulted by all dealing with the subject.

A point of interest in observations of these echoes is that the echo always has exactly the same wave-length as the signal. This suggests that the reflections occur at a surface which has no velocity relative to the earth otherwise a Döppler effect would be introduced, causing a change in wave-length.

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* *"Wireless Echoes of Long Delay." By P. O. Pedersen; Copenhagen. Andr. Fred. Host & Son. Kr. 2.40.*

NOTES & COMMENTS

We have to thank the Superintending Engineers of the Districts and their staffs for the hearty way in which they have responded to our request for particulars of difficult and interesting works carried out in their districts. Several articles of this nature appear in the present issue, but it is regretted that owing to lack of space some of the material has had to be carried forward. This position will soon straighten itself out and we trust to be able to continue as a feature of this journal to publish details of constructional and maintenance operations carried out under abnormal conditions.

Part 1 of the current volume is now out of print, but most back numbers are available and can be had on application to the Managing Editor.

FARADAY ELECTROMAGNETIC CENTENARY.

The arrangements initiated by the Royal Institution for the celebration of the Centenary of Faraday's discovery of electro-magnetic induction have already been announced. At the representative meeting held at the House of the Institution on February 5th, 1929, the formation of two committees was agreed to, and these committees are now at work. The first, consisting of representatives of the Royal Society, the British Association, and other scientific societies, as well as the Royal Institution, is concerned with the purely scientific aspects of Faraday's work in relation to the proposed celebrations; the second committee, which has been called together by the Institution of Electrical Engineers, consists of representatives of the principal organisations of those industries which have risen in the past hundred years upon the scientific foundation of Faraday's discoveries, and is dealing with the industrial aspects of the celebrations.

The two committees are working in close cooperation; the preliminary discussions which have taken place indicate that the significance of the Centenary is very widely appreciated and that the celebrations are likely to arouse worldwide interest and support. The dates have now been fixed, and the proceedings will commence in London on Monday, September 21st, 1931. Further, an intimation has been received from the British Association that their Centenary Meeting will be held in London during the week commencing September 23rd, 1931. These two Centenaries, with important electrical conferences and other events which are to take place about the same time, will thus conjoin to make the year 1931 a memorable one in this and every country where the genius of Faraday has borne fruit.

At the recent City and Guilds of London examination in Telegraphy, a candidate was unable to answer the questions and occupied himself by writing them out in full, and then gave a short essay on the constitution of the Government, terminating with the following confession :—

" I am writing all this nonsense as I am feeling dull with this book and pen. This is the result of not preparing the subject as I am laden heavily with work. Work alone does not matter but it is the worries and troubles that make one mad. Many of us do not realise until we come to the examination hall the folly of our not preparing the subjects with due care and energy. For all my troubles I am a big fool. So dear examiner, please forgive me for writing all this rubbish for I mean nothing after all. You need not go through this book and unnecessarily waste your very precious time. Just put a big " O " and finish off your duty and I shall be quite satisfied."

The foregoing may be of use not only to future examinees but also to some of the teachers.

THE EXAMINER.

MEMORIAL PANELS TO THE LATE MR. W. E. TWELLS.

Close upon one hundred persons were present at a simple yet impressive ceremony at the Holy Trinity Parish Church, Merton Road, on Wednesday evening, when two panels in the chancel were dedicated by the Vicar (the Rev. Alfred Thompson) to the memory of the late Mr. Walter Edgar Twells, for many years connected with the church and for several years people's warden, as well as superintendent of the Sunday School. The dedicatory tablet bears the following inscription : " To the dear memory of Walter Edgar Twells, born 27th February, 1873; died 21st April, 1928. Some time a warden in this Church." On the other tablet is a biblical quotation.

Wimbledon Borough News, 21.6.29.

The General Electric Co. (Peel Conner Telephone Works) has received an order for a further 100 Rural Automatic Exchange Units. This firm supplied the first 100 of these units, which are now almost all installed and working, and co-operated with the Department in the development of the apparatus known as " Unit Auto No. 5."

A description of this unit, together with photographs, appeared in the July issue of the Journal.

Mr. W. H. Peak, O.B.E., has recently resigned his position as Managing Director of The Relay Automatic Telephone Company Ltd., and he is succeeded by Major W. Burningham White and Mr. B. B. Johnson as Joint General Managers. Mr. Johnson has been Chief Engineer of this Company for many years, and Major Burningham White, who created the Sales Organisation, was General Sales Manager.

The Telegraph and Telephone Age of July 1st, 1929, announces the immediate establishment of a radio-telegraph system serving fourteen strategic cities in the United States, by the Radio Corporation of America Communications, Inc. The stations will be at New York, Chicago, San Francisco, Los Angeles, Seattle, Denver, New Orleans, Kansas City, Detroit, Cincinatti, Cleveland, St. Louis, Boston, and Washington. It is hoped to extend the system to a total of 29 cities. The establishment of the new service will give the inland cities direct connection with the wireless network radiating from New York and San Francisco to 22 foreign countries. Three million dollars have been set aside for the initial expenditure.

CANADIAN NATIONAL TELEGRAPHS TAKES OVER LAND LINES OF WESTERN UNION IN MARITIME PROVINCES.

Commencing with July 1st the Canadian National Telegraphs acquired and now operate the land mileage of the Western Union Telegraph Company in the Maritime Provinces of Canada, it is announced by W. D. Robb, Vice-President in Charge of Telegraph and Telephone services of the Canadian National Railways. Before this purchase the Canadian National Telegraphs had 153,066 miles of wire in service and operated 1,943 telegraph offices within the Dominion. The acquisition of the Western Union property in Canada adds to this 6,670 miles of wire and 188 offices, giving a total of 159,736 physical miles of wire under operation, and 2,131 offices. In addition to this physical mileage of wire, the Canadian National System has its carrier-current channels across the Dominion, on which twelve channels can operate at the same time in each direction, thus obviating the necessity for thousands of miles of individual mileage of wires. Up to the time of closing this new deal the commercial telegraph business on the lines of the former Intercolonial Railways had been operated by the Western Union Telegraph Company. The purchase of their property, Mr. Robb stated, gives to Canadian National Telegraphs complete control of all commercial telegraph facilities on the lines of the Canadian National System from Nova Scotia to British Columbia, and thus finally rounds out a complete transcontinental system. A few of the principal cities which will now be served by Canadian National facilities direct are Halifax, Sydney, New Glasgow, Truro and Yarmouth in Nova Scotia, Saint John and Moncton in New Brunswick, and Charlottetown, Prince Edward Island.—*Telegraph and Telephone Age.*

CANADIAN WIRELESS INDUSTRIES.

According to a preliminary statement issued by the Dominion Bureau of Statistics at Ottawa, the production of complete radio sets, parts and batteries in Canada during 1928, reach a value of $12,768,024, or 45 per cent. above the total of $8,789,171 reported for 1927.

In 1928 an output of radio sets or parts was reported by 45 different firms of which 39 were in the electrical supplies industry, 5 in the musical instruments industry and 1 in the furniture industry. This survey, however, does not include the great number of small custom workers who assemble or build to order, only those classed as manufacturers have been included. Complete sets were made in 14 different plants and the output numbered 81,032 sets worth $7,486,127, as compared with the corresponding total of 47,500 sets worth $3,748,622 in 1927. Vacuum valves were manufactured in 4 different factories; the number made was 1,556,917 and the value was $2,043,473. Batteries, storage and dry cell, said to be manufactured for radio purposes, were produced in 16 establishments and the value totalled $2,456,065 as against $2,572,993 for 1927. Battery eliminators were reported by 7 concerns and the output amounted to 3,219 worth $77,541. Other lines of production included transmitters, transformers, loud speakers, panels, condensers and other miscellaneous parts.

As reported to the Bureau by Mr. Lynn W. Meekins, United States Trade Commissioner at Ottawa, the exports to Canada of radio sets and parts from the United States during the Calendar year 1928, had a value of $5,264,642 and included the following items:—radio transmitting sets and parts, $255,434; radio receiving sets, $2,449,666; radio tubes, $173,843; receiving set components, $1,280,602; receiving set accessories, $1,105,097.

Radio licenses are issued by the Department of Marine and Fisheries. During the fiscal year ended March 31st, 1929, licenses were issued to 296,756 persons including 472 to the blind, as compared with 268,055 licenses issued in the preceding fiscal year. Ontario led all Provinces with a total of 144,842 and Quebec was next with 49,812. Registrations in the other Provinces in order were as follows:—Saskatchewan, 27,386; British Columbia, 23,480; Manitoba, 20,496; Alberta, 14,973; Nova Scotia, 8,611; New Brunswick, 6,289; Prince Edward Island, 756 and the Northwest Territories, 111.

Transmitting licenses were issued to 1,146 stations during the fiscal year, the following classes being included:—private commercial broadcasting; amateur broadcasting; limited coast; public commercial; experimental; private commercial; training school; amateur experimental; aircraft and ship.

We have been requested by the Relay Automatic Telephone Company to give notice to the effect that their telephone number at Marconi House, Strand, W.C.2, has been changed to "Temple Bar 1117."

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed:—

Exchange.	Type.	No. of Lines.
Aldridge	New Auto.	135
Archway	,,	3200
Beckenham	,,	3000
Bloxwich	,,	230
Colchester	,,	1140
Edgeware	,,	1300
Maida Vale	,,	7500
Reliance	,,	2700
Walsall	,,	1740
Epsom (Advance)	Auto Extn.	300
Kirkcaldy	,,	540
Bramhall	New Manual	1040
Canford Cliffs	,,	820
Parkstone	,,	1580
Southborne	,,	1880
Derby	Manual Extn	1060
Greenwich	,,	1080
Wednesbury	,,	440
Cheshire Sanatorium	P.A.B.X.	20
East London Rubber Co.	,,	50
Hazell Watson & Viney	,,	30
Kent Educn. Committee	,,	30
London Express	,,	40
Midland Bank, Ltd.	,,	670
Synthetic Ammonia	,,	100
Stalybridge Corpn.	,,	30
Tanganyika Concessions	,,	20
United Glass Bottles	,,	30
Yarmouth Corporation	,,	30

Orders have been placed for the following works:—

Exchange.	Type.	No. of Lines.
Ashton-on-Ribble	New Auto.	540
Blackpool (North)	,,	790
Blackpool (South)	,,	1745
Fulwood	,,	560
Granton	,,	1220
Gulliver	,,	4370
Leyland	,,	420
Portobello	,,	690
Preston	,,	3790
Castleton	Auto Extn.	100
Cowley	,,	200
Headington	,,	200
Southampton	,,	410
Whitworth	,,	100
Boscombe	New Manual	2300
Dorchester	,,	540
Farnborough	,,	780
Loughton	,,	1012
Eastbourne	Manual Extn	2120
Ramsgate	,,	440
Cerebos Salt Co.	P.A.B.X.	30
Cheltenham Corporation	,,	30
Co-op. Wholesale	,,	70
Hazell Watson & Viney	,,	30
Hunt & Winterbottom	,,	20
Hyde Co-op. Society	,,	20
International Paint Co.	,,	30
Shaw & Co.	,,	30
United Glass Bottle Co.	,,	30

MR. A. L. De LATTRE, I.S.O., M.I.E.E.

Mr. A. L. De Lattre entered the service at Birmingham in July, 1886, and was transferred to the Superintending Engineer's Office in September, 1891. Two years later he was promoted to Headquarters, where he immediately took up the duty of personal secretary to Sir John Gavey. He was closely associated with the work of valuing the Trunk Line Plant of the National Telephone Co. and later, prior to the complete transfer of the Company's undertaking to the State on 1st January, 1912, he was responsible for the labours of over 200 officers who were engaged for nearly two years in making an inventory of the plant. He had thus obtained an intimate knowledge of the Trunk system, in the development of which he has always taken the keenest interest. Mr. De Lattre was appointed Technical Officer in 1898, and in 1903 he was sent to Leeds as Assistant Superintending Engineer, where he introduced the Unit Maintenance Cost system and revised the Construction costing methods. Much useful information was obtained by these returns which proved of great value during the Arbitration Court proceedings

MR. A. L. DE LATTRE.

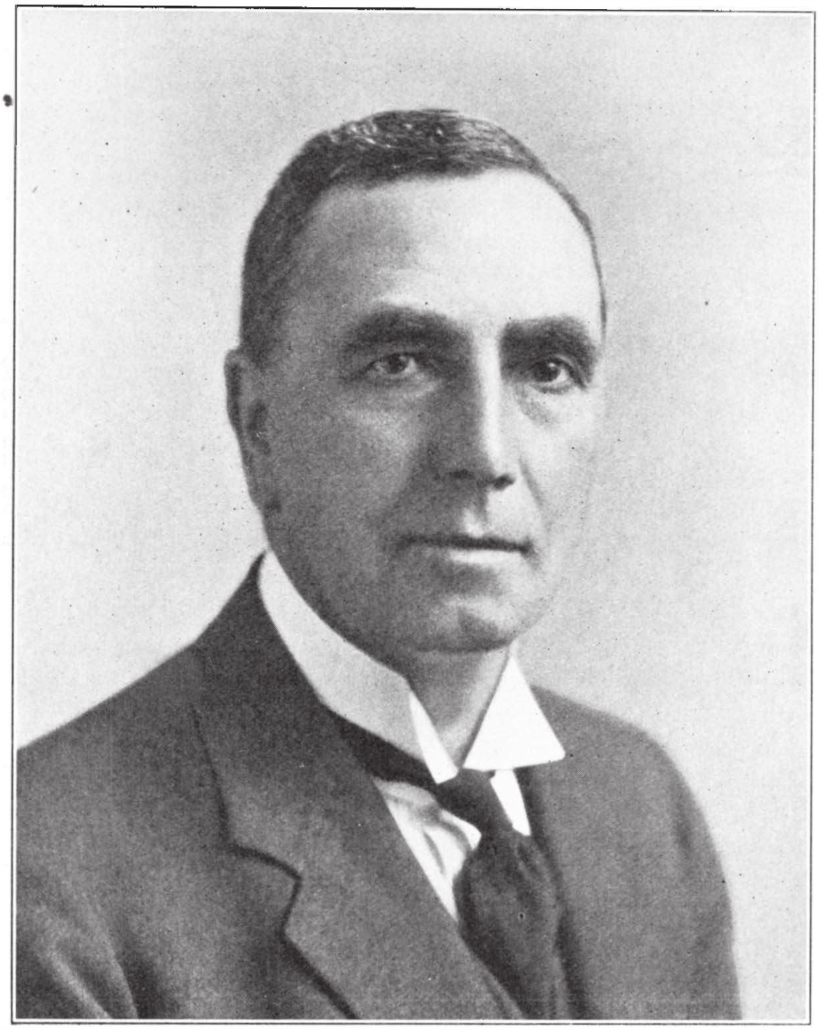
in 1912. After less than four years at Leeds, Mr. De Lattre returned to Headquarters to take charge of the Survey Section and later the Main and Local Lines Section. During the War his staff was seriously depleted, but the work of the provision of emergency lines and the operations of the submarine cable fleet, which at one time included six vessels, was energetically carried out, and after the Armistice the extensive line construction programme was pushed through under his enthusiastic supervision.

In 1921 Mr. De Lattre succeeded Mr. A. J. Stubbs as Assistant Engineer-in-Chief, and in this year's Honours List he received the honour of the Imperial Service Order.

Arrangements have been made for the presentation to Mr. De Lattre of a souvenir, but a date had not been fixed at the time of going to press and an account of the proceedings must therefore be deferred.

We wish Mr. De Lattre good health and many years of happiness in his retirement.

MAJOR H. BROWN, O.B.E., M.I.E.E.



MAJOR H. BROWN.

MAJOR BROWN succeeded Mr. De Lattre as Assistant Engineer-in-Chief as from the 1st September, 1929. So far as most of our readers are concerned Major Brown needs little in the way of introduction. A brief outline of his official and military career was given in the July, 1928, issue of this Journal on the occasion of his promotion to Superintending Engineer as from 1st June, 1928. He was at that time engaged, in conjunction with an Accounting Officer, on the special work of investigating methods and costs of construction in this country and he has continued on this work ever since. These duties have brought him into personal touch with a very large number of engineering officers of all grades.

During last autumn, Major Brown paid an official visit to the United States of America for the purpose of examining the organisation and methods of construction and maintenance followed in that country by leading Telephone and Telegraph Administrations. In the General Order announcing Major Brown's promotion, it is stated that he will act primarily as an efficiency engineer in charge of works organisation, output and costs. He will, therefore, continue to be actively associated with the lines of investigation which have kept him so busily occupied during the past few years.

MR. E. J. IVISON, M.I.E.E.

Mr. E. J. Ivison.

By the retirement of Mr. E. J. Ivison on March 31st last, the Engineer-in-Chief's Office lost one of its most popular and able Staff Engineers.

He was born on December 15th, 1868, and entered the C.T.O. on 6th February, 1886. Here he stayed until November 4th, 1892, when he resigned from the service to take up an unestablished position in the Electric Light Branch at Mount Pleasant. His outstanding abilities were very soon recognised, for on the 20th August, 1894, he was appointed a Sub-Engineer at Holloway Factory and three years later he was selected for the vacant Sectional Engineer's position at Northampton. On the 5th November, 1901, he was appointed 1st Class Engineer in charge of the Victoria Section, in connection with the introduction of manual common battery working in London. He was transferred to the staff of the Telephone Section in the Engineer-in-Chief's Office on the 11th January, 1907, and from that time, until his appointment as Staff Engineer in charge of that Section on 1st August, 1921, he ably filled the post of Assistant Staff Engineer under his three predecessors, Messrs. W. Brown, A. W. Martin and W. M. France.

It can therefore be truly said that, during the whole of his career, he has been very closely connected with every phase of telephone development.

The presentation of a silver tea and coffee service and autograph album took place in the Deputation Room, G.P.O. (North), and it is a rare occasion for such a large gathering to assemble and for such a pleasant and breezy atmosphere to prevail throughout the whole of the proceedings.

Col. Sir Thomas Purves, in making the presentation, said:

" The gap Mr. Ivison leaves behind him is a big and conspicuous one and one that causes a good deal of repercussion and reverberation. It is no disparagement to his able successor to say that he leaves a vacant place that will be very difficult to fill; he has been one of the Nestors of the Engineering Department, and his ability and his work have won him the respect of everyone of us. His character has won our very real and true affection. Never, in the course of the very many years I have known him, have I heard anybody say a disparaging or an unkindly thing about him, which I think is a very great thing indeed to be able to say about any man.

" I have sometimes wished that it might be possible to take the brain of a man like Mr. Ivison and transfer it ready stuffed with all kinds of wisdom and experience, most precious to the Department, to the head of some young stripling, ready to get a supply of young blood and to go on evolving in harmonious development. But I have no doubt that Mr. Ivison's views as to what he proposes to do with his brain are quite different! "

Words of affection, appreciation and goodwill were also spoken by Messrs. De Lattre, Shaughnessy, Medlyn, Bailey, Major Batchelor, Messrs. Hart, Hedley, Anson, Gibbon and O'dell.

Space is not available for the whole of Mr. Ivison's lengthy and witty reply, but the following extracts demand reproduction:—

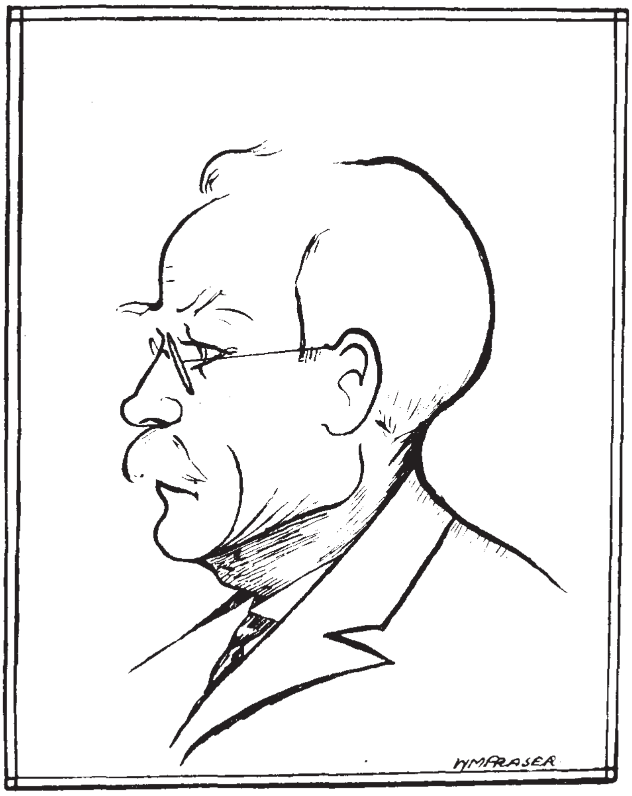
" With regard to all the kind words you have said to me to-day, I do not know how I am to reply. It has occurred to me that, possibly, if some of those kind words were said to a man when he was half way through—say about 40 years of age—whether they would make any difference to his career and would egg him on to greater things. But the experience of my early days rather tends to show that it would not be the right thing to do. When I went out (after Mr. Shaughnessy's experience) as a Sectional Engineer, at the salary of £150 a year—I had a very enjoyable time—I took out, amongst other things, a very heavy gang of men in charge of a foreman, who was a bit of a martinet, and the S.E. of the district went out with me on one occasion to visit them. Mr. Woods was the S.E., a very sincere man, and he told the foreman on this occasion that he thought a foreman, if he were any good at all, should encourage his men. I saw the foreman a few days later, and he seemed rather peeved about something. ' Well,' he said, ' this is a fine thing. I have to say to those chaps ' Jack; you have done a good day's work to-day.' Well, he goes home to his missus and says ' I must have been a blank fool; I shan't work so hard to-morrow.' So, after all, the praise is perhaps best when one has finished.

" I noticed in the paper the other day a revised version of the old joke which used to be built up round the P.O. Engineering Service, which I might repeat. Mr. Turner might like to have it filed in the Construction Section. The scene was an open manhole and a jointer's mate. An elderly and humble member of the Salvation Army, whose daily vocation seemed to be collecting washing, went up (as a daily good deed) to the jointer. ' My boy; do you know where Satan is? ' ' No,' said the man; ' but I will ask my mate,' and he proceeded to do so as follows: ' Bill; do you know where Satan is? There's a bloke here that's brought his dinner.'

" As regards what Mr. Bailey said regarding one's future prospects, there was a little incident at the Holloway Factory, when Mr. Stubbs came to see us and brought with him a tall young man, whom he introduced as Mr. Purves. Nobody there seemed to know him, and Mr. Catley, our senior officer, took Mr. Stubbs aside and said ' Who is Mr. Purves? ' Stubbs, in his characteristic way, said ' Not to know Purves is to argue oneself unknown.' That was a bit of persiflage. It must be a very insignificant person, at any rate, who has not heard of Col. Purves. I should like, if I may, at this juncture, to express my very sincere appreciation of the kind treatment he has always shown me and, I am perfectly certain, to the whole of his staff. I cannot let the occasion pass without saying that."

Our many readers who have been privileged to know Mr. Ivison will wish to join us in wishing him many happy years and the best of good health in his retirement.

MR. J. H. FOSSETT, B.Sc., M.I.E.E.



Mr. J. H. Fossett.

The retirement of Mr. J. H. Fossett on the 30th June last, on reaching the age limit, breaks another link with the pioneer days of electric lighting and power in the Post Office. Mr. Fossett entered the Service on the 16th February, 1891, and was placed in charge of a shift in the old G.P.O. (E) Electric Light engine room; that this was no sinecure job may be gathered from the fact that in those days one frequently worked in singlet and trousers in a temperature of 100°F. or more, endeavouring to maintain the supply of " juice " from the old two-pole dynamos which were prone to give elaborate firework displays on the slightest provocation and from locomotive boilers which were apt to send over steam accompanied at times by quantities of water with dire results on the working of the Willans high-speed engines and, incidentally, on the Shift Officer's temper.

However, Mr. Fossett successfully survived these hectic times, and, after spending four months in Edinburgh at the end of 1896 supervising the installation of E.L. in the Edinburgh G.P.O., was transferred to Cardiff at the end of 1896 where he supervised the installation and setting to work of the steam electric light and power station at Cardiff H.P.O., becoming a Second Class Engineer in December, 1897.

After spending two years at Cardiff Mr. Fossett was transferred to the Engineer-in-Chief's Office as Technical Officer in October, 1898; working in this capacity with Mr. H. R. Kempe, and under the late Mr. M. F. Roberts he dealt with the whole of the electric light and power work, including pneumatics, with conspicuous success at a time when there was very little past experience to go by and when the various branches of power work were not so highly specialised as they are in these days.

Mr. Fossett was created 2nd Class Staff Engineer in November, 1904, and Asst. Superintending Engineer in July, 1906, in which capacity he served in the Ireland, Scotland West and Met. Power Districts and eventually returned to the Engineer-in-Chief's Office in September, 1918, where he remained till the date of his retirement.

During this latter period he was responsible for the introduction of automatic working on street pneumatic tubes and also for the design and equipment of the automatic pneumatic tube centre at the War Office. This installation, which necessitated a large amount of original work, was the first of its kind in this country and, as far as is known, in any other country, and besides effecting some thousands of pounds annual saving resulted in a very much improved service to the telegraph offices in the neighbourhood. The working has been so satisfactory that it has been decided to adopt similar apparatus for the C.T.O. tube installation; other installations are also contemplated.

A keen walker and outdoor enthusiast, Mr. Fossett should find no lack of congenial occupation in his retirement and his friends will wish him many years of good health and happiness.

LONDON ENGINEERING DISTRICT.

Mileage Statistics.

During the three months ended 31st March, 1929, the following changes have occurred:—

Telegraphs.—A nett decrease in open wire of 15 miles and a nett increase of 81 miles in underground.

Telephone Exchanges.—A nett increase in open wire of 427 miles and a nett increase of 19,247 miles in underground.

Telephone (Trunk).—A nett decrease in open wire of 18 miles and a nett increase of 4,545 miles in underground.

The total single wire mileages at the end of the period under review were:—

Telegraphs	26,215 miles.
Telephone Exchanges ...	2,517,225 ,,
Trunk	84,904 ,,
Spares	120,637 ,,

Number of Telephones. — The following figures show the changes in the number of exchange lines, extensions and stations during the three months ending and the totals at 30th June, 1929:—

	Increase.	Total.
Exchange Lines ...	6,840	370,066
Extensions ...	6,926	315,520
Stations	12,306	623,894

Telephone Exchange Progress.

New Automatic Exchanges.—The following exchanges have been opened during the past three months:—

Exchange.	*No. of equipped lines.*	*Manufacturer.*
Beckenham	3,000	Siemens.
Reliance	2,700	General Electric Co.
Maida Vale	7,500	Siemens.
Edgware	1,300	General Electric Co.
Fulham	7,500	Standard T. and C.
Metropolitan	9,500	A.T.M.
National	9,500	A.T.M.
Mitcham	1,480	Siemens.
Flaxman	9,900	General Electric Co.
Hendon	4,200	A.T.M.

Two New Manual Exchanges have been opened, viz.: — Emberbrook (Ferry Road, Ditton) on the 31st July. Equipped for 1,660 lines.

Stanmore C.B. No. 1 on the 18th September. Equipped for 800 lines.

Exchange Transfer (Manual). — Chancery Manual Exchange was transferred from 55, High Holborn, to 329, High Holborn, on the 27th July. 1,279 Subscribers and their associated Junctions were affected. The "Chancery" and "Terminus" subscribers are now accommodated on manual equipment made spare by the opening of Holborn Automatic Exchange.

Exchange Extension.—The capacity of the Greenwich Exchange has been extended by 1,200 equipments.

C.C.I. Extensions.—The rapid increase in the number of Automatic Exchanges is necessitating a revision of the C.C.I. provision at many Manual Exchanges. At the moment the C.C.I. positions are being increased at Grosvenor, Abercorn, Speedwell, Brixton and Langham, whilst preliminary steps are in hand for early extensions at 27 Exchanges.

Fire at Sidcup Exchange.

Elsewhere in this Journal reference is made to the unfortunate accidents to external plant in the London District. Since the article was written, there has been another serious disaster, but on this occasion it was the internal plant that was affected. On the evening of Saturday, August 10th, a fire occurred on premises adjoining the Sidcup Telephone Exchange and spread to the roof of the exchange. When the fire was extinguished it was found that the telephone switchboard had been completely destroyed. Men and material were quickly mobilised and a rapid survey made to ascertain how and where a temporary exchange could be established. Careful examination indicated that space on the ground floor of the burnt building could be cleared and made fit to accommodate switch sections. A temporary roof was formed of waterproof material, and the work of installation commenced at once. A number of the most important lines, such as those serving fire stations, police, ambulance and hospitals, were connected to adjacent exchanges up to the limit of the available circuits. These were put through in a few hours. Work proceeded continuously in the provision of the new switchboard, and within six days the whole of the circuits had been restored in such a manner that the work looks as if it had been deliberately planned and was intended to serve for several years. As there were 1,200 working subscribers and a large number of junctions this was no mean achievement, and the Sectional Engineer (Mr. A. Warner) and his staff well earned the commendation they received.

The attached extract from the " Sidcup and Kentish Times " indicates that when subscribers and the Press are allowed to know something of the work involved in restoring service after a disaster and the strenuous efforts made to shorten the period of dislocation appreciation takes the place of criticism.

" A WORD OF PRAISE.

" The general public of Sidcup and Chislehurst will, we feel sure, extend a word of praise to the General Post Office engineering staff and General Post Office traffic workers for re-instating the dislocated telephone service at the Sidcup Exchange within a short period of seven or eight days. Last Saturday week the upper part of the building in Station Road, Sidcup, was devastated by fire and a vital section of the plant, the switch-board, impaired beyond use.

" It says much for the engineering staff that emergency lines were linked up with Eltham Exchange within a few hours after the outbreak and a partial service thus resumed. A new switch-room had at once to be prepared on the ground floor, and an entirely new switch-board erected and connected with the power plant. This was most intricate and painstaking work which must be seen to be appreciated. Work normally taking many weeks to do was accomplished in a little over a week, and in cramped conditions which rendered the task extremely difficult.

" In the near future a new and more spacious building is to be erected at the rear of the premises in Station Road, and Chislehurst is also to have its own Exchange.

" Apart from the engineering staff, a word of praise should be given to our telephonists in a most trying time. Throughout the past ten days they worked heroically and unremittingly. Normally they put through from 120 to 140 calls an hour, which gives some idea of how frequently the service is required. Any subscriber interested in the work of the Exchange is at liberty to pay a visit during the coming week."

RETIREMENTS AND TRANSFERS.

Many changes in personnel have recently taken place in the District and others are pending. If an officer who left the District two or three years ago were to return in the course of the next few months he would be astonished at the changes in the Sections. Messrs. Appleby and Wells have retired and their positions in charge of the Centre External and North East External Sections respectively have been taken by Messrs. Mitton and Jones. Mr. Aspinall has been promoted to take charge of the North West External Section. Mr. Steed has retired and his position as Sectional Engineer at the Central Telegraph Office has been taken by Mr. Deane. Mr. Phillips, Assistant Engineer in the West External Section has retired, and Mr. Watkins, another well known Assistant Engineer, has been promoted Executive Engineer at Bangor.

All those who have retired have spent many years in the London District and their loss will be keenly felt. They have fully earned their period of rest, as their tenure of office has included some of the most strenuous years in the history of the Engineering Department. Those of us who remain behind to carry on the work hope that our late colleagues will have many years of quiet enjoyment and that they will not forget those whom they inspired by their good example.

TELEPHONE ORDER TABLES.

At the request of one of the large stores in the West End three mahogany tables, each 13 feet long, have been supplied and fixed. On each table is fitted telephone keys and answering equipment for 10 order clerks, who will receive orders for goods and answer enquiries from customers.

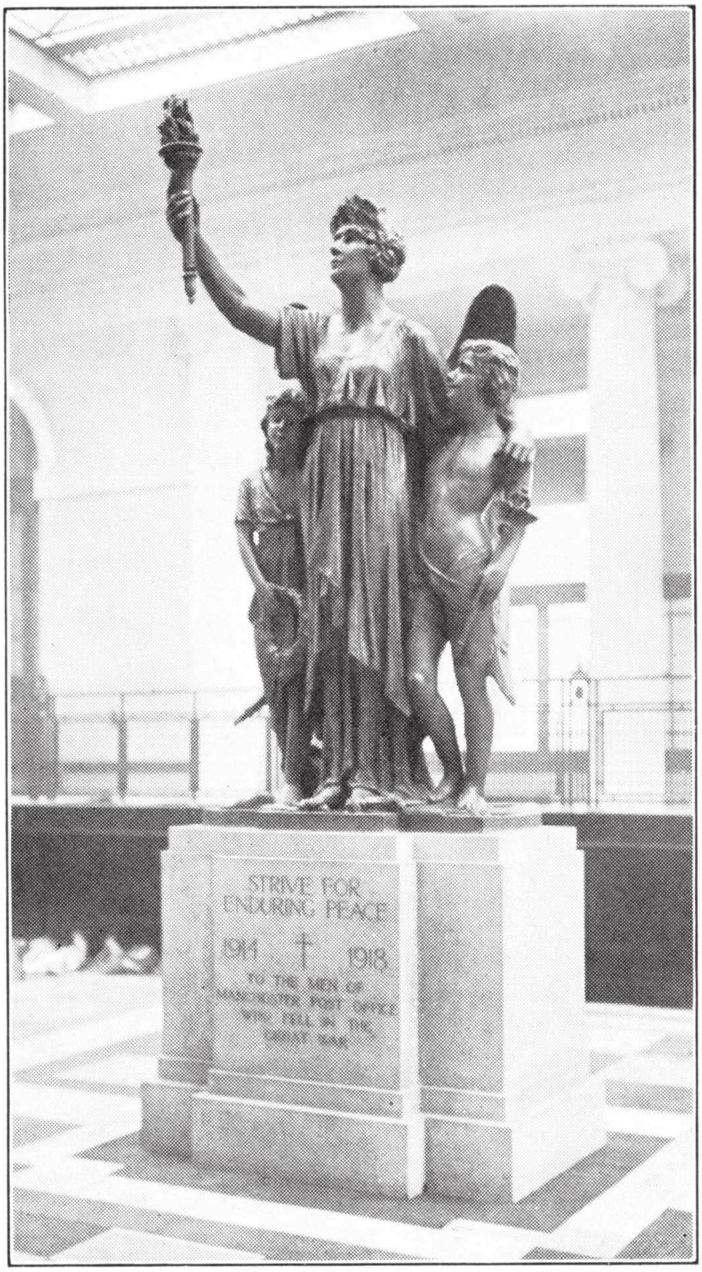
TELEGRAPHS.

In connection with the introduction of the Totalisator at Race Meetings 55 baseboards have been equipped for teleprinter working. Special cases have also been made to facilitate transport.

BATTERIES.

The District Staff has just completed the installation of two 10,000 ampére-hour batteries at the City Exchange in replacement of the original lead tank batteries of much smaller capacity.

LOCAL CENTRE NOTES.



Manchester H.P.O. War Memorial.

SOUTH LANCS. CENTRE.

Manchester Post Office Staff War Memorial.—Coincident with the opening of the new public office at the Manchester Head Post Office in March last, a memorial was dedicated to those members of the Post Office Staff who gave their lives in the Great War. The memorial consists of a bronze group by Mr. J. Ashton Floyd, A.R.C.A. (Sc. Lond.), in which Peace is symbolised by a woman of noble form and serene countenance, pressing forward with her message to the peoples of the world and leading a youth and a maiden, the rising generation, to an era that knows not War. They tread under foot, as

they pass, the Sword, Helmet and the Shield. The message is summed up in the motto:—
"Strive for enduring peace."

Visit to works.—On July 3rd, a party of about 60 members paid a visit to the Shipbuilding and Engineering Works of Messrs. Cammell Laird & Co., Ltd., Birkenhead. The visit was thoroughly enjoyed and the facilities granted for inspecting this Company's excellent organisation were greatly appreciated.

SOUTH EASTERN DISTRICT.

Honour for S.W.2 Officer.—The following extract from the "Hastings and St. Leonards Observer" of the 15th June, 1929, refers to Mr. C. A. Jezzard, who is a skilled workman at Hastings:—

"The first warrant officer in the whole of the R.N.V.R. throughout the British Empire, Signal-Boatswain C. A. Jezzard, has been awarded the M.B.E. in the birthday honours list recently issued.

"Mr. Jezzard, who is a son of Mr. Walter Jezzard, J.P., joined the R.N.V.R., Hastings Sub-Division, in January, 1909, under Lieut. Breeds. He was called upon for war service in August, 1914, as a Yeoman of Signals and served with the Mediterranean and the Ægean Fleets. During hostilities he was promoted to Chief Yeoman of Signals. The R.N.V.R. was reorganised after the war, with Lieut.-Commander John Bray in charge of the Hastings Sub-Divisions.

"Mr. Jezzard has the further distinction of becoming the first Signal-Boatswain in August, 1923, and being the first R.N.V.R. officer to be awarded the M.B.E. He will attend the Prince of Wales' investiture at St. James' Palace on July 9th. The Prince will act for His Majesty the King."

On the 1st October, 1929, Mr. T. Cornfoot, Assistant Superintending Engineer, is due to take over the control of the North Ireland District. Mr. J. H. M. Wakefield, Executive Engineer, Guildford, will succeed Mr. Cornfoot at Croydon.

Telephones.—The abnormally high rate of increase of telephones in the District, which has been maintained for several years, still continues. During the Quarter ended 30-6-29 the % increase on total stations in the District was 3.1, this rate being the highest in the country.

Exchange Transfers.—Deal Exchange, with 680 stations, was successfully transferred from Magneto to C.B. on the 13th July, 1929.

Work in connection with the transfer of the Maidstone Area, from C.B., C.B.S. and Magneto, to Automatics is in hand. The Area comprises the following Exchanges:—Maidstone, Bearsted, Hunton, Otham, Wateringbury, Aylesford, Boughton Monchelsea, and Barming.

Cables.—The new loaded and balanced cable, Chichester to Portsmouth, is nearing completion.

Two new 14 pair continuously loaded cables will shortly be laid from Canterbury Repeater Station to Dumpton Gap, and Sandgate respectively, for connection to proposed submarine cables.

Reflectors for Overhead Line.—Trial is being made of reflectors on poles as a warning to traffic. If these reflectors are satisfactory the painting of poles will be much reduced.

NORTH OF IRELAND CENTRE.

GEORGE LASLETT.

The 1st July, 1929, marked the retirement from the Service of Mr. George Laslett, Sectional Engineer, Belfast.

With very genuine regret we record the official passing of our old friend, for his sterling qualities of heart and mind had endeared him to us all.

Mr. Laslett's service extended over 46 years. Entering the Service at Folkestone it was not long before he found his way to the Central Telegraph Office, London, where he was employed from 1891 to 1897. He then entered the Engineering Department as a Sub-Engineer, successively holding the appointments of Engineer Second Class in the old Met. District, London, being transferred to Met. South on division of the District and subsequently Executive Engineer, Londonderry and Belfast.

During his long service in Ireland he passed through many stirring periods and saw important changes in the Administration, not the least of these being the partition of the Six Counties from the rest of Ireland and the formation of the Northern Ireland District.

On the occasion of his retirement Mr. Laslett was entertained by the Members of his Staff and many friends at a smoking concert when he was presented with a silver tea service.

Major G. H. Comport, M.C., M.I.E.E., R.E., Superintending Engineer, presided and in making the presentation referred in feeling terms to the loss he personally sustained on Mr. Laslett's departure from the Service. After referring to Mr. Laslett's ability as an Administrator and the feeling of confidence and respect in which he was held by all ranks he went on to review the many large works with their associated difficulties (many of which were peculiar to Northern Ireland) accomplished since he (Major Comport) took charge of the District and which had been executed under Mr. Laslett's control.

After observing that Mr. Laslett was going away in splendid health with many years of life in front of him, in asking his acceptance of the memento of the occasion he said he hoped he and Mrs. Laslett would be spared for a very long time to enjoy a well-earned leisure and in that leisure he wished them peace and good health.

Many of those present paid tributes of the excellent qualities possessed by the guest and to the loss they personally would feel at his retirement. In particular Mr. Davidson referred to his close association with Mr. Laslett, extending over 17 years, and to the fact that during all that time the most cordial relations had always existed.

Mr. Laslett, in responding, thanked the company for their kind expression of good wishes and for the handsome present of which they had made him recipient. He wished also to thank the Staff of all ranks for their loyal support and said that he felt he had always been served conscientiously and well.

NORTH WALES CENTRE.

Mr. George Richardson.

On his retirement from the position of Executive Engineer of the Birmingham (Internal) Section on the 30th June last, Mr. Richardson was within a few weeks of completing his forty-seventh year of Post Office service.

Mr. Richardson's official career began in the Telegraph Department at Hull in August, 1882, and he served at that office until December, 1895, when he was appointed 2nd Class Junior Clerk at the Superintending Engineer's Office of the old South Midland District, which was at that time located at Birmingham. In 1897 he was promoted to a 1st Class Junior Clerkship in the Superintending Engineer's Office at Newcastle-on-Tyne, and in 1901 on his promotion to a 2nd Class Engineership he was transferred to London to take part in the Post Office scheme for the telephoning of London.

After six years' service in the old Central Metropolitan District, Mr. Richardson was transferred to the Telephone Section of the Engineer-in-Chief's Office where he stayed until 1909, when he was promoted to a 1st Class Engineership, and placed in charge of the Birmingham Section. A year later he was withdrawn from sectional duties to take part in the important work incidental to the transfer of the National Telephone Company's plant to the Post Office. This work occupied two years, and on its termination at the end of 1912 he resumed his duties as Sectional Engineer at Birmingham.

Mr. Richardson's administrative ability and tactful personality, which have always been characteristic of him, found ample scope during this transition period in the task of amalgamating the Post Office and the Company's staffs. His success in this direction is gratefully remembered by those who served under him at that time, and during the succeeding years.

Mr. Richardson combined an unvarying urbanity with a very strong devotion to official duties, which he not merely practised himself but impressed upon the staff under his supervision. He set a very high standard in this respect, and was at all times available for consultation with any of his subordinates when difficulties arose. This close personal contact with his staff went far to arouse the esteem of his assistants, who recognise the value of the training they received at his hands.

Mr. Richardson's extra-official activities should not go unrecorded. In his earlier days in London as an Engineer he was a member of the original committee of the Society of P.O. Engineers, and he also served on the Council of the Institution of P.O. Electrical Engineers. His interest in the North Wales Centre of the I.P.O.E.E. has always been keen, both as a member of the committee, and as a ready participant in the discussions at the meetings. Latterly, he served on the committee of the

South Midland Centre of the Institution of Electrical Engineers. From 1914 to the end of his service he also did much unobtrusive work in connection with the Post Office Relief Fund.

It is a pleasure to be able to record that Mr. Richardson is retiring from the service in the best of health, and being a man of varied interests it is extremely unlikely that his retirement will be spent in inactivity. In taking leave of him, his staff, his many friends in other Districts, and, it must be added, in other Public Departments in Birmingham, salute him with affectionate regard and wish him every happiness for the future.

At a largely attended smoking concert arranged in his honour, Mr. Richardson was presented with a silver tea and coffee service. Mr. R. A. Weaver, Superintending Engineer, in making the presentation, spoke of his knowledge of Mr. Richardson so far back as 1896, and stated that he would be recognised as a good example of a type of officer who had played a memorable part in the history of the Post Office Engineering Department and as a colleague whose conduct had been based on the highest standard of duty. Many other speakers including Mr. G. W. Billingham, his close colleague in Birmingham for many years, and Mr. C. W. Piggott (Traffic Superintendent), also paid eloquent tributes to Mr. Richardson's striking personality and sterling qualities.

A.E.S.

NORTH MIDLAND CENTRE.

Mr. F. G. Browne.

A successful and enjoyable evening was spent on the 26th July, when a representative gathering of members of the Coventry Section Staff expressed their good wishes to Mr. Browne at a smoking concert held at the Railway Hotel, Coventry, on the occasion of his retirement.

The chair was taken by Mr. H. Kemp, Sectional Engineer, and high tribute to Mr. Browne's capacity and industry, combined with an ability to appreciate the other man's point of view, which gained him great popularity and esteem, was paid by speakers representing every grade in the Section. Mr. Kemp referred specially to the important and arduous work done by Mr. Browne in connection with the inauguration of the Coventry Automatic Exchange for which he took the principal responsibility.

During the evening a presentation was made and this (at Mr. Browne's request) took the form of a microscope.

Mr. Browne's Official career is given in the following details:—

1884	Assistant to Postmaster at Pontypridd.
1887	Acting Telegraphist, Bristol.
1888	Telegraphist, Bristol.
1890	S. C. & T., Birmingham.
1899	Junior Clerk S.E.'s Office, Birmingham.
1902	Sub-Engineer, Northampton.
1907	2nd Class Engineer, Northampton.
1911	Assistant Engineer, Leamington and, later, Coventry.

In 1910 Mr. Browne spent 11 months in the Construction Section of the E/C.'s Office and was then employed on the Inventory of the ex-N.T. Co.'s plant until October, 1912.

G.F.P.

ANNUAL REPORT ON THE POSTS AND TELEGRAPHS DEPARTMENT, FEDERATED MALAY STATES, YEAR, 1928.

The following extracts were taken from the report for the year 1928:—

Telegraphs.

During the year 428,834 telegrams were despatched and 454,438 telegrams were delivered, being a decrease of 9.6 per cent. in the telegrams despatched and a decrease of 10.2 per cent. in the number delivered, as compared with 1927. The revenue shows a decrease of $32,153 or 6.5 per cent. from that of 1927. The value of telegrams sent free of charge for Government Departments was $50,468, a decrease of $9,086.

Telegraph facilities were extended to the new post offices at New Town, Ipoh, and Tanjong Tualang. An additional quadruplex set and an automatic duplex Wheatstone set were installed in the Kuala Lumpur office and were of material assistance in disposing of telegraph traffic at times of pressure.

At the larger telegraph offices increased use has been made of typewriters for the reception of telegrams, with improving results. Telegrams are typed direct from sound from the telegraph instrument, and, as the operators become expert at reading the telegraph instrument and using the typewriter simultaneously, not only is there more rapid reception but a much more business-like copy of the message is delivered to the addressee. A departmental typewriting class was instituted early in the year and has been successful in turning out a number of competent telegraphists.

By arrangements with the Eastern Extension Australasia and China Telegraph Company, Limited, regulations were again issued for the acceptance at any telegraph office in the Federated Malay States of " Christmas and New Year Greeting Telegrams" for a long list of countries, at rates which approximated to one-quarter of the ordinary charges.

TELEPHONES.

The number of subscribers to the telephone system on the 31st December, 1928, was 4,534, an increase of 531 as compared with 1927. In addition there were 2,177 extension lines, extension bells, private circuits, private bell or alarm circuits and tell-tale clock circuits maintained by the department, as compared with 1,871 in 1927.

The revenue derived from telphones was $1,196,884, an increase of $134,322 over 1927. The trunk revenue amounted to $384,914, an increase of $67,534 as compared with the previous year.

Thirteen new public telephone exchanges were opened in the course of the year. On 31st December, 1928, there were 59 public exchanges in the Federated Malay States.

There were 90 public telephone call boxes available at post offices and postal agencies throughout the country.

The average number of originated calls per direct exchange line per day was 11.3, a decrease of about 8 per cent. as compared with the average figure for 1927.

The average total numbers of originated calls per day throughout the Federated Malay States during the year were:

Local calls	41,000
(increase over 1927, 2 per cent.)	
Junction calls	2,800
(increase over 1927, 180 per cent.)	
Trunk calls	4,300
(decrease from 1927, 4.4 per cent.)	
Total originated traffic... ...	48,100
(increase over 1927, 5.3 per cent.)	

The approximate total originated telephone traffic during the year was as follows:

Local calls	11,972,000
Junction calls	817,600
Trunk calls	1,255,600
Total originated traffic ...	14,045,200

During the year the junction system of operating non-local calls, that is, giving connection on demand, was introduced in the Ipoh, Klang, Kuala Lumpur and Seremban districts, effecting a material improvement in the telephone service on short-distance inter-exchange traffic. The large increase in the number of junction calls and the decrease in the number of trunk calls in the year under review was due to the introduction of this junction system of working.

Development studies were made in a large number of existing and proposed telephone exchange areas in the course of the year, for the purpose of estimating plant and equipment requirements. A comprehensive estimate of future trunk and junction requirements was also made.

The plans of the new building to accommodate the proposed Kuala Lumpur automatic exchange were approved and the specification for the exchange was prepared and despatched to the Crown Agents in the latter part of the year.

The " Rural Automatic Unit " referred to in paragraph 45 of the report for 1927 arrived in the country at the end of the year and arrangements were well in hand to bring it into service at Dengkil, Selangor, early in 1929.

An automatic private branch exchange was established in the Federal Secretariat building to serve 25 extensions. Experiments on other automatic units were made during the year.

Arrangements have been made for the "Carrier current" system of telephony to be introduced between Kuala Lumpur and Ipoh, and the necessary apparatus arrived in the country towards the end of the year. This system will permit a considerable economy in line plant to be effected and will enable the northward trunk traffic to be handled more expeditiously than can be done at present.

ENGINEERING.

On the 31st December there were 2,926 miles of telegraph and telephone lines and 23,691 miles of overhead wire in the Federated Malay States, of which 20,555 miles were telephone wires. In addition there were 121 miles of underground cables containing 11,428 miles of wire single line. These figures do not include the poles and lines maintained for its own use by the Railway Department. The Posts and Telegraphs Department also owns and maintains 123 miles of line and 612 miles of wire in Johore. It also maintained in 1928 two miles of pole line for Kedah, 900 miles of wire for Johore and 24 miles of pole line in the Dindings.

The underground system was considerably extended and strengthened during the year, a total additional cable mileage of over 19 miles having been laid, giving an additional single wire mileage of over 1,520 miles.

WIRELESS.

Seventy-four temporary licences for the use of wireless receiving apparatus were issued during the year, and two experimental transmitting licences.

The British official news broadcast from the wireless station at Rugby in England, received at Penang Wireless Station and transmitted from Penang by land-line for delivery to the local newspapers on payment of a monthly fee, averaged 21,390 words a month.

The two ½-kliowatt short-wave wireless sets referred to in paragraph 59 of my report for 1927 were put into operation early in the year and tests were carried out between Kuala Lumpur and Singapore and Penang and between Kuala Lumpur and various places in Pahang. These tests showed that continuous-wave low-power transmissions could be relied upon to maintain a regular internal telegraph service but the sets did not yield telephonic results of sufficient dependability at the distances required. The experiments were carefully logged and the results tabulated and recoded.

The wireless station at Port Swettenham, and a number of wireless sets which had been used on launches engaged in the prevention of rubber-smuggling, were taken over from the Customs Department on the 23rd July. The Port Swettenham station has been put in good order and at the close of the year arrangements were in train for the inauguration of a Ship-to-Shore Radio Service early in 1929.

With the two ½-kilowatt sets and with certain of the ex-Customs sets, expeditiously converted to short-wave working, the following temporary wireless stations were installed against the contingency of floods in Pahang:

Kuala Lumpur (Petaling Hill); Kuantan (Mobile); Kuala Lipis; Kuala Pahang; Temerloh; and Mentakab.

The floods came, and the land-line between Raub and Kuantan was unworkable from the 24th to the 31st December. During this period the whole of the Pahang Coastal and the Trengganu traffic was sent by wireless between Kuala Lumpur and Kuantan. Nine hundred and fifteen messages were so dealt with, and a large number of Government messages were also cleared between the other emergency stations. Plans for the economical consolidation of this provisional flood-proof communication scheme were in preparation at the close of the year.

CURRENT LITERATURE.

The Journal of the Institution of Electrical Engineers, Vol. 67, No. 390, June, 1929.

The Construction of the " Grid " Transmission System in Great Britain. Johnstone Wright and C. W. Marshall, B.Sc., Members. The paper gives an outline of the chief constructional features of the system of high-voltage transmission lines being constructed under the provision of the 1926 Electricity Act. The main supply is 3-phase, 132,000 volts between phases, 50 cycles per second. Maps and certain constructional drawings are given.

The Development of the Oxide-Coated Filament. B. Hodgson, O.B.E., B.Sc., Ph.D., L. S. Harley, B.Sc. (Eng.), Associate Member, and O. S. Pratt, B.A. Paper reviews the development, describes in outline present day manufacturing practice, and indicates the most recent views on electron emission from alkaline earth oxides.

The Operation of Several Broadcasting Stations on the same Wave-length. Captain P. P. Eckersley, Member, and A. B. Howe, M.Sc. Consideration is given to the advantages to be derived from and the means whereby the operation of several stations may be attained.

Vol. 67, No. 391, July, 1929.

Voice Frequency Telegraphs. W. Cruickshank, Member. The paper discusses the position of telegraphs in this country, comparing it with those of Germany and the United States. Multiplex A.C. transmission is considered and the limits to its use determined. The various systems in use are described and proposals are advanced for its wider adoption in this country. The main arguments against its adoption are economic, but some technical criticism is included.

Report of the Council for year 1928-29, presented at the Annual General Meeting, 9th May, 1929.

Discussion on " Overhead Electrical Lines " at Western, Liverpool, Scottish, East Midland Centres and author's (W. B. Woodhouse) reply.

Discussion on " The Attenuation of Wireless Waves over Land " and Mr. R. H. Banfield's reply.

Vol. 67, No. 392, August, 1929.

The Fifth Faraday Lecture, " How Electricity does Things." Ll. B. Atkinson, Past-president.

Electrical Insulating Papers for the Manufacture of Power Cables. T. N. Riley, D.S.C., M.Sc., Member, and T. R. Scott, D.F.C., B.Sc., Associate Member.

The Prevention of Ionization in Impregnated Paper Dielectrics. S. G. Brown, F.R.S., Member, and P. A. Sparing, M.Sc., A.I.C.

An Investigation of Short Waves. T. L. Eckersley, B.A., B.Sc.

A Portable Radio Intensity-Measuring Apparatus for High Frequencies. J. Hollingworth, M.A., D.Sc., Member, and R. Naismith, Associate Member.

The Action of a Reflecting Antenna. L. S. Palmer, Member, and L. Ley K. Honeyball.

Discussion on the " Grid " Transmission System from No. 390.

Journal of the American Institution of Electrical Engineers, June, 1929.

Standard Voltage A.C. Network. John Oram. A description of the Dallas (Texas) underground lighting and power network.

Railway Train Signal Practice. P. M. Gault.

Electrical Wave Analysers for Power and Telephone Systems. R. G. McCundy and P. W. Blye. The paper describes two types of analysers. The telephone circuit analyser operates over frequency range from 75 to 3,000 cycles and measures harmonic currents as low as 0.05 microampere and voltages down to 0.005 millivolt, even in the presence of fundamental and other harmonics relatively large.

Interconnection in the South West. Geo. A. Mills, Member. Eight States, 720 miles by 810 miles, are now connected by a continuous transmission system, operated at 60,000 volts or more.

Bare Wire Overhead Distribution Practice. M. C. Miller.

Illumination Items. Light Therapy. Report on use of Incandescent Lamps in Motion Picture Photography.

July, 1929.

Master Reference System for Telephone Transmission. W. H. Martin and C. H. G. Gray. The system described is the Master Reference System of the Bell System for the expression of transmission standards and the ratings of the transmission performance of telephone circuits. A replica of this system installed in Paris has been adopted as the Master Reference System of the International Advisory Committee on Long Distance Telephone Communication in Europe and thus provides a common reference for American and European ratings.

Telephone Circuits for Programme Transmission. F. A. Cowan. Networks of telephone circuits extensively used in the transmission to broadcasting stations are described. The general requirements for satisfactory transmission are enumerated and the maintenance of the networks is discussed. A plan of the Bell System Programme network, covering 31,350 miles, is given.

Meeting Long Distance Telephone Problems. H. R. Fritz and H. P. Lowther, Jr. A discussion of the problems as solved in the South-western Bell Telephone Company's area.

August, 1929.

The Engineer, Practical Idealist. President's Address. R. F. Schuchardt.

Telephone Transmission Networks. T. E. Shea and C. E. Lane. A brief resumé of the nature of telephonic signals is given, and a basis for the design of networks to transmit them is provided. Networks and apparatus must give efficient transmission, low distortion, good impedance balance, stability, low reflection, must not cross-talk into associated circuits and must have desirable impedance characteristics to cover a wide frequency range.

Trans-Atlantic Telephone Cable. The new cable will yield only a single telephone circuit, the main length being about 1,800 nautical miles. It will be continuously loaded with "perminvar" and insulated with "paragutta." It is hoped to cope with an attenuation of about 150 decibels for the higher frequencies. To make two-way operation possible, voice-operated switching mechanisms will be required at the two terminals.

BOOK REVIEWS.

"Les Appareils Transporteurs Mecaniques de Bureau." By J. Jacob. 230 pp. Published by M. M. Dunod, 92 Rue Bonaparte (VI.), Paris.

This book, written by the Engineer-in-Chief of the French Postal and Telegraph Services, covers comprehensively the various methods of transporting messages, letters, documents and parcels in buildings, a subject on which comparatively little has been written hitherto.

Although dealing largely with the necessities of the postal services, the work is by no means limited to these, but deals also with cash handling systems in shops, and generally with the subject of internal transport in offices and stores. Choice of system is discussed and details of erection and maintenance given.

After dealing with spiral and straight chutes where the motive power is gravity, and simple devices controlled by hand, catapult or electric motor, a large section of the book is devoted to pneumatic house tubes and their auxiliary plant. Methods of arranging the tubes are shown and the power units described, while consideration is given to various methods of economising power.

Wire, rope, and moving belt conveyors are also fully dealt with, while, in the final chapters of the book, conveyors and chutes are considered especially in connection with the simplification and reduction of work in Sorting Offices, examples being given of actual and projected installations.

Owing to the illustrations with which the book is amply provided, the book is easy to follow without any profound knowledge of French, full details of apparatus being given as well as general arrangements.

T. McG.

"Engineering Electricity." By Ralph G. Hudson, S,B. Chapman & Hall, Limited. 214 pages. 12/6 nett.

This book contains an outline of the basic principles of electrical engineering, both A.C. and D.C., applied particularly to electrical machinery. It has been written particularly for engineers who, while being desirous of becoming thoroughly acquainted with the fundamental principles of the subject, cannot study it in detail. Descriptive matter is reduced to a minimum, but about 40 pages are devoted to photographs of apparatus, machinery and switchgear by which their mode of construction is well illustrated. A large number of useful problems together with answers are also included. The keynote of the book is brevity, and it is therefore likely that it would prove useful for the purposes of quick revision prior to examination of medium standard in Electrical Engineering.

H.C.J.

We have to acknowledge the receipt of the following publications:—

From International Standard Electric Corporation: Two copies of a translation into English of the C.C.I. Proceedings in Paris, 11th to 18th June, 1928.

From Siemens Bros.: Pamphlet 508*a*, Siemens Neophone. A description of the new C.B. microtelephone developed and manufactured by the Company. Details of this instrument are published elsewhere in this issue. Pamphlet 510*a*, Small Rural Automatic Equipment No. 26.

A Report of the Gemuntelejken Telephone Service, Rotterdam, for the year 1928.

A Similar Report from the Danish Telephone Companies, Copenhagen, for 1928.

From Evershed and Vignoles: A pamphlet covering the firm's new Bridge Meg Resistance Tester. As the Meg evolved from the Megger, so has the Bridge Meg Tester been developed from the former. The instrument is self-contained and is assembled in an aluminium alloy case which can be carried in the hand or slung over the shoulder. Its range is from 0.01 ohm to 100 megohms. No external resistance is required when the instrument is used on "Bridge." The switches are of new design and are very compact and efficient. Only two terminals are fitted.

From Bureau of Standards: Code for Protection against Lightning.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

Provisional Programmes of Centres for Session 1929-30.

LONDON CENTRE.

Dates to be fixed later.

A. B. Hart, M.I.E.E.
Chairman's Address.
A. Speight, A.M.I.E.E.
"The Development of Automatic Routiners in the British P.O."
E. S. Ritter, M.I.E.E., D.F.H.
"Picture Telegraphy."
J. N. Hill.
"Critical Methods of Investigation as applied to the Study of Telephone Area and Plant Layout."
A. C. Timmis, B.Sc., A.M.I.E.E.
"Carrier Current Telephony."
A. Morris, A.R.C.Sc., M.I.E.E.
"Telephone Cable Circuit Interference."
J. A. M. Owen and J. A. S. Martin.
"Composited Telegraph and Telephone Working."

Informal Meetings.

1929.	
22 Oct.	Chairman's Address.
26 Nov.	H. Y. Starkey. *To be announced later.*
1930.	
28 Jan.	W. C. Burbridge. "Some Development Heresies."
25 Feb.	A. Miller. "London Building Acts."
25 Mar.	W. A. Williams. "Thoughts on Staff Efficiency."
22 Apl.	E. J. Barnes. "Loud Speakers."

NORTHERN CENTRE.

1929.	
16 Oct.	A. S. Renshaw. *(E.-in-C.O.).* "Some Considerations Relating to the Clerical Organisation of the Engineering Dept."
20 Nov.	F. W. Gaskins, A.M.I.E.E. "Cabling of the Tyne and other Tyne Bridges."
1 Dec.	J. W. Hastings. "The Teleprinter and possibilities of its Development."
1930.	
15 Jan.	R. T. Robinson, A.M.I.E.E. *(E.-in-C.O.).* "Motor Transport in the P.O. Engineering Department."
19 Feb.	R. Parker. "The Middlesbrough Automatic Telephone System."
19 Mar.	W. T. Gemmell. "The Heating and Ventilating of Post Office and Telephone Exchanges."

NORTH EASTERN CENTRE.

1929.	
8 Oct.	J. W. Atkinson, M.I.E.E. Chairman's Address.
12 Nov.	E. S. Ritter, M.I.E.E., D.F.H. *(E.-in-C.O.).* "Picture Telegraphy."
10 Dec	R. T. Robinson, A.M.I.E.E. *(E.-in-C.O.).* "Motor Transport."
1930.	
14 Jan.	A. Morris, A.R.C.Sc., M.I.E.E. *(E.-in-C.O.).* "Telephone Cable Circuit Interference."
11 Feb.	H. E. Francis. "Rural Automatic Exchanges."
11 Mar.	H. McLean. "Notes on Insulating Materials."

NORTH WESTERN CENTRE.

1929.
14 Oct. W. H. Lane
"Telephone Transmission." A brief description of the standard arrangements for giving effective transmission to telephone subscribers.
12 Nov. A. Morris, A.R.C.Sc., M.I.E.E. *(E.-in-C.O.).*
"Telephone Cable Circuit Interference."
9 Dec. A. S. Renshaw. *(E.-in-C.O.).*
Subject to be announced.
1930.
— Jan. Visit to Automatic Telephone Manufacturing Company's Works, Liverpool.
10 Feb. A. S. Carr (Cantab), A.M.I.E.E., and E. Hopper, A.M.I.E.E.
"Blackpool Telephonic Repeater Station."
10 Mar. T. Woodhouse, A.M.I.E.E.
"Cells."

SOUTH LANCS. CENTRE.

1929.
14 Oct. W. J. Medlyn, M.I.E.E.
Chairman's Address.
11 Nov. H. M. Turner.
"Small Power Rectifiers."
16 Dec. *To be arranged.*
1930.
13 Jan. *To be arranged.*
11 Feb. S. S. A. Watkins, B.Sc., A.M.I.E.E. *(Western Electric Co., Ltd.).*
"Talking Films.'
(Joint meeting with the I.E.E.).
10 Mar. *To be arranged.*
7 Apl. S. Jackson.
"Manchester Repeater Station."

NORTH WALES CENTRE.

1929.
9 Oct. R. A. Weaver, M.I.E.E.
Chairman's Address.
14 Nov. E. S. Ritter, M.I.E.E., D.F.H. *(E.-in-C.O.).*
"Picture Telegraphy."
11 Dec. Major C. A. Blackwell.
"Fault Procedure."
1930.
8 Jan. Capt. N. Cave-Brown-Cave.
"Sound."
12 Feb. A. Morris, A.R.C.Sc., M.I.E.E. *(E.-in-C.O.).*
"Telephone Cable Circuit Interference."
12 Mar. H. P. Lloyd
"Electrolysis."

SOUTH WALES CENTRE.

1929.
14 Oct. A. Morris, A.R.C.Sc., M.I.E.E. *(E.-in-C.O.).*
"Telephone Cable Circuit Interference."
11 Nov. P. O. Sullivan.
Visit to B.B.C. Station. Investigation of wireless complaints.
9 Dec. C. W. Brown, A.M.I.E.E. *(E.-in-C.O.).*
"Automatics."
1930.
13 Jan. S. G. Rickard.
"E.L. and Power: Administrative procedure regarding Statutory and 48 hours' Notices."
10 Feb. C. G. Heighton.
"Cable Balancing and Sheath Current Tests."
10 Mar. A. C. Timmis, B.Sc., A.M.I.E.E.
"Carrier Current Telephony."

NORTH MIDLAND CENTRE.

1929.
30 Sept. *To be arranged.*
4 Nov. Mr. Ede.
"Fitters and their work."
2 Dec. *To be arranged.*
1930.
6 Jan. *To be arranged.*
3 Feb. Mr. Coote.
"Some Aspects of Maintenance in Auto Exchanges."
3 Mar. Mr. Warrand.
"Main and Local Lines: Plans and Records."

SOUTH MIDLAND CENTRE.

1929
2 Oct. J. E. Taylor, M.I.E.E (Chairman).
"Electro-magnetic Theories."
6 Nov. A. S. Renshaw. *(E.-in-C.O.).*
"Some Considerations relating to the Clerical Organisation of the Engineering Department."
4 Dec. W. H. G. Naylor.
"Telephone Repeater Apparatus, Theory and Use."
1930.
8 Jan. W. L. Taylor.
"Motor Vehicles."
5 Feb. L. G. Gosh.
"Underground Works. Negotiations with Road Authorities."
5 Mar. E. S. Ritter, M.I.E.E., D.F.H. *(E.-in-C.O.).*
"Picture Telegraphy."

EASTERN CENTRE.

1929.
— Oct. Visit to the Cambridge University Labs.
5 Nov. A. Morris, A.R.C.Sc., M.I.E.E. *(E.-in-C.O.).*
"Telephone Cable Circuit Interference."
1930.
14 Jan. S. G. Last.
"The Abnormal Development of Southend-on-Sea and the Transfer to Auto-External."
11 Feb. C. A. Mitchell.
"Southend's Automatic Telephones."
18 Mar. A. C. Timmis, B.Sc., A.M.I.E.E. *(E.-in-C.O.).*
"Carrier Current Telephony."

SCOTLAND EAST CENTRE.

1929.–1930. Programme not yet available.

SCOTLAND WEST CENTRE.

1929.
7 Oct. Informal Meeting.
2 Dec. A. D. Kier.
"Local Experience on Contract Work."
1930.
20 Jan. A. Morris, A.R.C.Sc., M.I.E.E. *(E.-in-C.O.).*
"Telephone Cable Circuit Interference."
3 Feb. J. D. McLeod.
"Glasgow-Wemyss Bay Cable—Drawing-in, Balancing and Locating."
3 Mar. R. McWhitter, B.Sc., Dip. R.T.C.
Subject to be announced later

SOUTH WESTERN CENTRE.

1929.
8 Oct. A. Morris, A.R.C.Sc., M.I.E.E. *(E.-in-C.O.).*
" Telephone Cable Circuit Interference."
12 Nov. A. E. Millard. *(E.-in-C.O.).*
" Rural Automatic Exchanges."
10 Dec. G. E. H. Body.
" Telephonic Repeaters."
1930.
14 Jan. A. Bucklitsch.
" Maintenance Work and Costs."
11 Feb. E. S. Ritter, M.I.E.E., D.F.H. *(E.-in-C.O.).*
" Picture Telegraphy."
11 Mar. *To be arranged.*

NORTH IRELAND CENTRE.

1929.
22 Oct. Chairman's Address, to be followed by exhibition of film " Voices Across the Sea."
28 Nov. R. T. Robinson, A.M.I.E.E. *(E.-in-C.O.).*
" Motor Transport in the Post Office Engineering Department."
1930.
14 Jan. A. H. Jacquest, A.M.I.E.E. *(E.-in-C.O.).*
" Trunk Exchange Construction."
11 Feb. W. S. French.
" Rural Automatic Exchanges."
18 Mar. J. G. Morrow.
" Wireless "—
(*a*) " Broadcast Interferences. Their causes and remedies."
(*b*) " Brief description of Trans-Atlantic working."
14 May Visit to Messrs. Harland & Wolff's Shipbuilding Yards."

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Institution of P.O.E. Engineers,
G.P.O. (Alder House), E.C.1.

or the undermentioned gentlemen who have kindly agreed to act as representatives of the Institution in their respective countries :—

R. Badenach, Esq., B.Sc. (Melb.),
Chief Engineer's Office,
Postmaster-General's Department,
Treasury Gardens,
Melbourne, C2,
Australia.

H. C. Brent, Esq.,
District Telegraph Engineer's Office,
Wellington, N.Z.

N. N. Banerjee, Esq., A.M.I.E.E. (Ind.),
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Calcutta West Division,
8, Wellesley Place,
Calcutta,
India.

A. T. Kingston, Esq., M.B.E., A.M.I.E.E.,
Office of the Chief Engineer,
Telegraphs & Telephones,
C.T.O.,
Colombo,
Ceylon.

A. J. Kellaway, Esq.,
Department of Posts and Telegraphs,
P.O. Box 366,
Pietermaritzburg,
South Africa.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to	Date.
Brown, Major, O.B.E.	Superintending Engineer N. Midland District.	Assistant Engineer-in-Chief.	1-9-29
Gilbert, A. B.	Assistant Superintending Engineer, Scot. East District.	Superintending Engineer, N. Midland District.	1-9-29
Cornfoot, T.	Assistant Superintending Engineer, S. East District.	Asst. Suptg. Engineer-in-Charge, N. Ireland District.	1-10-29
Fulcher, H. W.	Executive Engineer, Central Power Section, London District.	Assistant Superintending Engineer, London District.	6-6-29
Blight, W. O.	Acting Assistant Staff Engineer, Equipment, Section, E.-in-C.O.	Assistant Staff Engineer, Equipment Section, E.-in-C.O.	2-8-29
Wakefield, J. H. M.	Executive Engineer, Guildford Section, S. Midland District.	Assistant Superintending Engineer, S. East District.	1-10-29
Kingston, Major J. R., O.B.E.	Executive Engineer, Power Section, E.-in-C.O.	Acting Assistant Staff Engineer, Power Section, E.-in-C.O.	2-8-29
Witherby, J. C.	Assistant Engineer, Glasgow South Section, Scot. West District.	Executive Engineer, Hereford Section, S. Wales District.	1-8-29
Gilbert, D. P.	Assistant Engineer, Power Section, E.-in-C.O. Acting Executive Engineer.	Acting Executive Engineer, Power Section, E.-in-C.O. Executive Engineer.	12-7-29 2-8-29
Beeton, H. C.	Assistant Engineer, South Power Section, London District.	Acting Executive Engineer, Central Power Section, London District.	2-8-29
Bignell, L.	Chief Inspector, Technical Section, S. Eastern District.	Assistant Engineer, Technical Section, S. Eastern District.	8-7-29
Bruce, R.	Chief Inspector, N. Ireland District.	Assistant Engineer, Liverpool (Intl.) Section, S. Lancs. District.	To be fixed later.
Worthy, L. F.	Chief Inspector, City (Extl.) Section, London District.	Assistant Engineer, East (Extl.), Section, London District.	8-7-29
Townsend, S. B.	Chief Inspector, Sheffield Section, N. Mid. District.	Assistant Engineer, Middlesbro' Section, N. District.	1-8-29
Hill, J. N.	Chief Inspector, Technical Section, London District.	Assistant Engineer Technical Section, London District.	17-7-29
Milton, G. P.	Chief Inpector, Telephone Section, E.-in-C.O.	Assistant Engineer, Lines Section, E.-in-C.O.	To be fixed later.
Husband, S. J.	Clerical Officer, Equipment Section, E.-in-C.O.	Chief Inspector, Equipment Section, E.-in-C.O.	To be fixed later.
Saite, G. P.	Skilled Workmen, Class I., S. Eastern District.	Inspector, S. Eastern District.	,,
Prudden, R. W.	,, ,,	,, ,,	,,
Hoad, S. E.	,, ,,	,, ,,	,,
Milne, J.	,, ,,	,, ,,	,,

TRANSFERS

Name.	Rank.	From	To	Date.
Manning, G.	Assistant Engineer	London District.	E.-in-C.O.	24-7-29
Salter, L. F.	Assistant Engineer	E.-in-C.O.	London District.	1-7-29
Wright F. V.	Assistant Engineer	S.W. District.	E.-in-C.O.	1-9-29
Gilbert, J.	Inspector	Scot. E. District.	London District.	30-6-29
Bridges, J. T.	,,	N. E. District.	S.E. District.	6-8-29
Shaw, J. W.	,,	,,	London District.	25-8-29
Whittaker, A. W.	,,	N. W. District.	,,	1-7-29
Salt, R. S.	,,	E. District.	E.-in-C.O.	23--6-29
Britton, G. A. C. R.	,,	S. Mid. District.	,,	23--6-29
McMillan, D.	,,	London District.	,,	1-8-29
Helman, S. L.	,,	,,	,,	1-8-29
Dudley, J. C.	,,	,,	,,	1-8-29
Lewis, N. W. J.	,,	,,	,,	1-8-29

Retirements.

Name.	Rank.	Districts.	Date.
De Lattre, A. L.	Assistant Engineer-in-Chief.		31-8-29
Hardie, J.	Assistant Superintending Engineer.	Scot. West.	14-9-29
Lakey, T.	Executive Engineer.	E.	15-9-29
Davey, F. W.	,, ,,	E.-in-C.O.	31-8-29
Chambers, J. L.	Assistant Engineer.	Scot. West.	31-5-29
Beer, G. F.	,,	S. Lancs.	14-6-29
Dwyer, J. J.	,,	S. Mid.	13-7-29
Ancell, W. J.	,,	S.E.	8-6-29
Browne, F. G.	,,	N. Mid.	28-7-29
Phillips, F. J.	,,	London.	31-7-29
Teggins, A. W.	,,	S. Mid.	31-7-29
Greenfield, G.	Chief Inspector.	London.	31-7-29
Atkinson, J. S.	,, ,,	Testing Branch.	20-6-29
Roy, J. D. B.	Inspector.	Scot. East.	3-6-29
Garrett, P. J.	,,	London.	17-5-29
Aitchison, J. W.	,,	S. Lancs.	28-5-29
Bebington, A. E.	,,	London.	30-6-29
Jackson, G.	,,	Scot. W.	25-8-29

Resignations.

Name.	Rank.	District.	Date.
Willis, F. B.	Assistant Engineer.	E.-in-C.O.	30-6-29
Riley, J. H.	,,	,,	10-7-29
Hedley, D. J.	Inspector.	,,	7-7-29

Deaths.

Name.	Rank.	District.	Date.
Addis, C.	Inspector.	Oxford Radio.	4-7-29
Hollis, W. A. J.	,,	N. Wales.	24-8-29

CLERICAL ESTABLISHMENT.

Promotions.

Name.	Grade.	Promoted to.	Date.
Harrop, F. N.	Higher Clerical Officer, S. Lancs. District.	Staff Officer, S. Lancs. District.	2-7-29
Aspden, S. C.	Assisting Executive Officer, E.-in-C.O.	Executive Officer, E.-in-C.O.	15-7-29
Child, A. J.	Clerical Officer, E.-in-C.O.	Acting Executive Officer, E.-in-C.O.	15-7-29

RETIREMENTS.

Name.	Grade.	District.	Date.
Weir, A. W.	Staff Officer.	S.W.	10-6-29
Whiteside, J. G.	Higher Clerical Officer.	N. Wa.	2-7-29
Jones, E. J.	Executive Officer.	E.-in-C.O.	14-6-29

TRANSFERS.

Name.	Rank.	From	To	Date.
Harris, W. T.	Staff Officer.	S. Lancs. District.	S. West District.	11-6-29

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THE
Post Office Electrical Engineers' Journal

SUMMARY OF INAUGURAL ADDRESS BY COLONEL SIR THOMAS F. PURVES, PRESIDENT, I.E.E.

Delivered before The Institution, 24th October, 1929, and published here by the kind permission of the Institution.

AFTER acknowledging his election to the office as a tribute of friendship and goodwill to himself and as a gracious compliment to the P.O. Engineering Department, the President proceeded to discuss the question of the education of the engineer. He was of the opinion that the teaching of detailed applications of technology in the schools will have to be abandoned. The fundamental technique of electrical science and engineering, and its general application, already furnish more than sufficient material for a full college course. We may well be content if the graduates are men with sound fundamental knowledge and with faculties trained to continue the processes of absorption and assimilation, men who know what the tools of science and technology are and how they can be used, and if possible endowed with vision and enterprise.

Sir Thomas then made reference to Mr. F. Gill's address in 1922, and after claiming a place in the sun for the " milliampere man " he reviewed the position of automatic telephony and the progress made, both in London and the provinces, since his own paper on the subject five years ago. It is anticipated that in seven years' time the number of automatic exchanges in the central London business area will have reached 100, leaving only five manual exchanges for subsequent conversion. In this country there are now 163 automatic exchanges operating in urban areas with about 500,000 stations; automatic equipment capable of serving about 100,000 lines is being installed annually. At the present rate about 1,000 new telephones are installed each working day throughout the year. Rural automatic exchanges, giving a 24-hours per day service, are being installed in simple buildings of the " garage ' type and are left unattended beyond a weekly visit from a lineman.

Line economics was then treated and the importance of detailed surveys, which take into account all the known social and commercial factors of growing and changing localities, was emphasised. These surveys have to be revised from time to time, in order that adequate plant may be laid down for growth, without unduly spending capital on unproductive ducts and cable. In the development of the service in this country, new telephone stations and increased use of those already existing are necessary. Reluctance to hire a telephone and to use it after it has been hired may be a British characteristic, but the Engineer-in-Chief is quite sure that it is not an unchangeable characteristic.

A feature of communications engineering is the manner in which electrical considerations affecting the transmission line have advanced into prominence. The author paid a tribute to the work of Oliver Heaviside, the pioneer in the art of adding inductance to a line possessing inherent capacity, Pupin and Campbell, and then proceeded to discuss modern practice with regard to loading, showing the relations between propagation speeds and frequencies with different loadings. Attenuation and distortion can be reduced by compensating networks, but cross-talk must be eliminated before repeaters could be relied upon entirely if loading were omitted. Never did the seed of an invention fall upon more fruitful ground than did the telephone repeater, developed on the basis of De Forest's conversion of the Fleming valve into a triode amplifier, and never was a long-standing fundamental problem solved in a more complete and satisfying manner. Two-wire and four-wire repeaters, echo suppressors and repeater refinements were then touched upon. The speaker next proceeded to deal with the work of the C.C.I., and how the work of telephoning Europe internationally had proceeded amicably and steadily through the united efforts of the various administrations. The transmission units agreed upon by the C.C.I.—and incidentally also by America—were defined and explained, and mention was made of the Standard Reference System set up in Paris, which is owned and operated by the C.C.I.

The enormous advances made in the Radio field were detailed; the Rugby station, which is capable of reaching any properly equipped ship in any part of the globe; the wonderful service of broadcasting throughout the world; and the trans-Atlantic circuits between London and New York which link together all the millions of telephone users in America and in Europe. The original long-wave channel forms the main link, but there are also two short-wave channels, each using waves of the order of 16, 24 and 30 metres and radiating 5 kW, against the 60 kW of the long-wave channel, and apparatus for a third short-wave channel is in course of construction. The combination of the two systems ensures practically a 100 per cent. service. The President explained the single side-band method of transmission used on the 5,000 metre channel, and pointed out how improvement had been effected by a careful location of stations; the short-wave channels have the advantage of directional transmission and reception, which imparts a certain measure of privacy. On the long-wave service, the elimination of the carrier, and the suppression of one side-band entirely and non-essential portions of the other present difficulties to would-be listeners, but methods of securing secrecy have been devised and close attention is being given to their development. Many of the special features of the trans-Atlantic radio system are devices intimately connected with, and in some cases borrowed from, the developments of line telephony.

Work is now going forward actively at the Bell Telephone Laboratories on the development of a continuously loaded telephone cable for connection between London and New York, and it is possible that the cable (which will yield only one telephone channel with probably a telegraph channel superposed) will be available for service as early as 1932. The loading material will be one of the series of alloys designated as "perminvars." These are composed of nickel, iron and cobalt to which may be added small amounts of non-magnetic metals such as molybdenum. "Perminvars" are characterised by high resistivity and by a wonderfully constant permeability over a wide range of magnetising force. The conductor will be insulated with a new dielectric material known as "paragutta," which is similar in mechanical properties to gutta percha, but the combination and treatment of its constituents endow it with superior electrical properties, approximately equal to those of tightly packed dry paper. The attenuation on the cable will be immensely greater than that of any other telephone circuit yet planned, the ratio of input to output being about 10^{15}, or 150 decibels, for the high frequencies of the voice range. It is anticipated, however, that the received speech will be successfully amplified and passed forward in good shape to the next section of the line. The end repeaters will be single-direction amplifiers and voice-operated switching mechanisms will be employed to control the direction of transmission.

The great success achieved in the trans-Atlantic service has led to investigations into the possibilities of opening telephone services with the British Dominions. Experimental trials have been maintained for some time between this country and Australia, and it is hoped that a commercial service will be opened very soon, to be followed later by services to South Africa, India, New Zealand, etc.

To illustrate the enormous advance made in world wide communications, and also the successful application of the thermionic valve repeater, the President quoted details of a circuit extending from Stockholm to America, crossing that continent 2½ times and terminating in New Jersey, over which a fair grade of conversation was maintained. (Details of the circuit were given in this Journal, April, 1928). The transmission equivalent of the chain would not be less than 240 Bels, *i.e.*, the ratio of power sent to power received would be 1 to 10^{-240}. To deliver 1 micro-watt at the far end without repeaters on such a circuit would require the application of the energy of the entire universe × 10^{177} !

A description of the operation of the photo-cell and its application to fac-simile transmissions and also to the "talkies" concluded the address. [See note under Notes and Comments.]

BROADCAST OF PRESIDENTIAL ADDRESS TO I.E.E.

A. J. Aldridge, A.C.G.I., A.M.I.E.E.

As will be known to many readers, the inaugural address of Sir Thomas Fortune Purves, Engineer-in-Chief, G.P.O., as President of the Institution of Electrical Engineers, was broadcast to local centres of the Institution, and particulars of the arrangements made on that occasion may be of interest.

It was originally intended that all the local centres, including Dublin, should be included in the arrangements, but this was not found possible on account of the shortage of suitable lines. Ultimately, the following towns were linked up, viz., London, Glasgow, Newcastle, Leeds, Liverpool, Manchester, Birmingham, Cardiff, Southampton and Portsmouth. In London, at the Institution, arrangements were also made whereby all the speeches could be heard from loud-speakers in the Library and the tea room. The scheme proposed was that the President's address should be broadcast from loud-speakers at each of the local centres, the vote of thanks being proposed by Mr. Harcourt Williams at Manchester, and seconded by Prof. McLean at Glasgow. The vote of thanks and the seconding thereof were to be broadcast from loud-speakers at all stations, including London. In addition, arrangements were made whereby, on the retiring President addressing each station in turn, before the presidential address, they could each, in turn, announce to all the others that they were in session.

The general outlines of the arrangements were settled at a meeting of representatives of the Lines, Telephone and Research Sections, and it was then agreed that the conditions could be most satisfactorily met by the use of four-wire circuits to each place. To prevent howling, it was decided to hand switch the lines from "Talk" to "Listen" as required; except during the preliminary roll call, this would not involve any special precautions. Details are given later. The Research Section was to select patterns of suitable transmitters and loud-speakers, to provide models of the amplifiers required, and to be responsible for the provision of all the equipment required at the Institution Building in London. The Telephone Section arranged for the provision of all the local equipment, from the models supplied, and for making all the local arrangements in conjunction with the Districts concerned. The Lines Section selected and tested the various lines required and made all arrangements for the necessary switching.

Microphones.—To pick up the President's speech it was decided to make use of a condenser microphone as being likely to give the best results. Actually a condenser microphone, designed and built in the Research Section, was used with a four-stage amplifier. The amplifier circuit is shown in Fig. **1**.

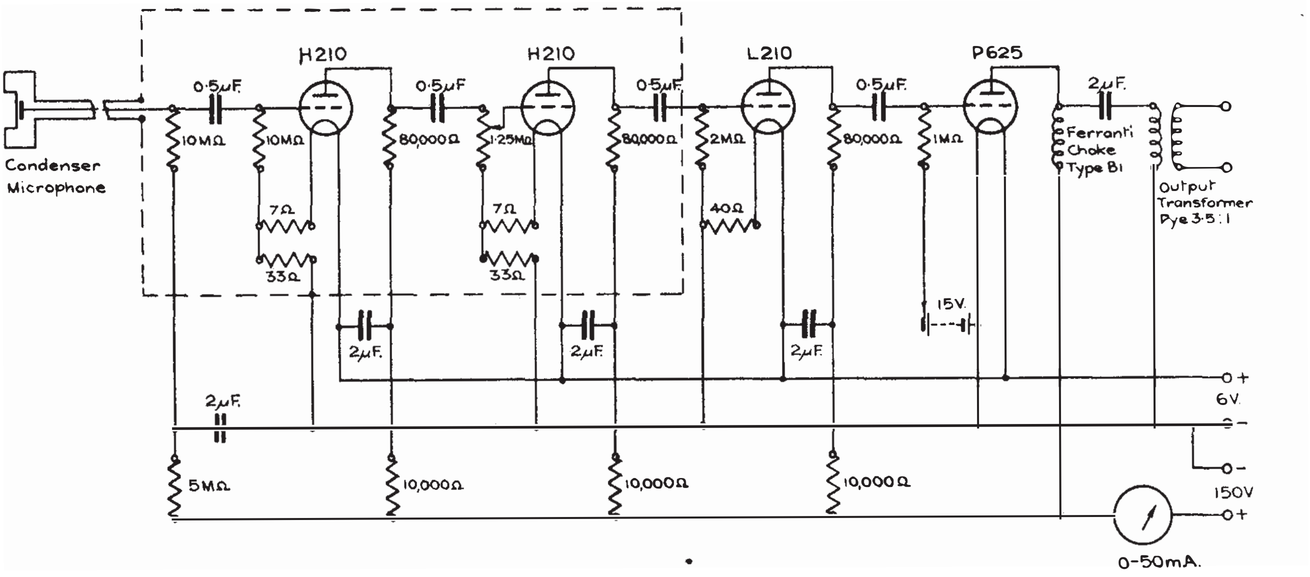

FIG. **1**.

speaker. These instruments thus modified were actually used, mounted in small wooden cases. Spoken to from two or three feet away, they only need one stage amplifiers; the circuit for these is shown in Fig. **2**. The H.T. used was 150 volts from W size dry cells. The four 0.1 mfd. condensers in series on the amplifier output were provided to give some tone control. Two condensers in series were actually used. Each station was provided with a spare microphone.

For the local stations it was not thought necessary to provide condenser microphones. A sufficient number of these were not available at the time and, moreover, a somewhat sensitive amplifier is required. Good results from the point of view of articulation had been obtained with microphones as used in the new microtelephones about to be brought into service, and it was found in some preliminary trials, that if the damping were increased, they would give excellent results, even when used to a loud-

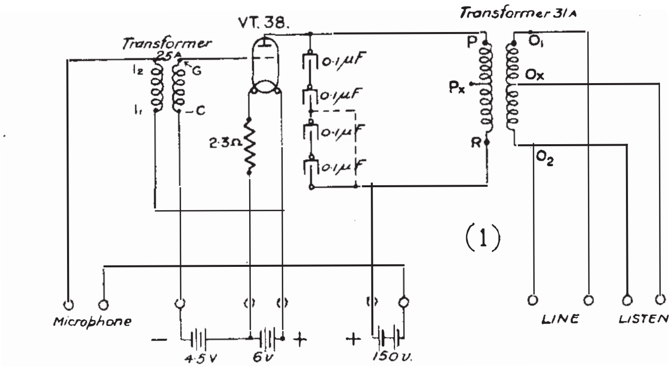

FIG. **2**.

Lines and Switching.—Preliminary tests indicated that to obtain a natural tone from the loud-speakers it would be necessary to make use of lines with a higher cut-off than is normally required for speech transmission. It was found that a nominal cut-off of not less than 4000 ∿ was advisable and this limited the number of available lines. Fig. **3** shows diagrammatically the arrangement finally adopted. The main switching point was at Leeds, with secondary switching points at the London repeater station (for Southampton, Portsmouth, Leeds and the Institution) and at Manchester (for Liverpool). At each switching point it will be seen the microphone lines and the loud-speaker lines were connected to keys, so that any selected microphone line and all the loud-speaker lines, except that associated with the particular microphone line, could be coupled together as required. The lines actually used are given in the accompanying table. " Speaker " lines were allotted at each place and arranged to be cut over if required to the working circuits should any fault develop on these.

DETAILS OF LINES USED IN I.E.E. BROADCAST.

Section.	*Conductor.*	*Loading.*	*Cut off frequency.*
London—Leeds	20lb. Side Circuit	44 mh. at 1.136 miles	5570 ∿
Leeds—Edinburgh	20lb. Side Circuit	44 mh. at 1.136 miles	5570
Edinburgh—Glasgow	40lb.	Unloaded Phantom	—
Leeds—Newcastle	20lb. Part Side Part Phantom	89 mh. at 1.136 ,, 47.3 mh. at 1.136 ,,	3920
Leeds—Derby	20lb. Part Side Part Phantom	89 mh. at 1.136 ,, 47.3 mh. at 1.136 ,,	3920
Derby—Birmingham	20lb. Side	89 mh. at 1.136 ,,	3920
Leeds—Derby	20lb. Phantom	22 mh. at 1.136 ,,	6300
Derby—Cardiff	20lb. Side	89 mh. at 1.136 ,,	3920
Leeds—Manchester	40lb.	Unloaded Phantom	—
London—Portsmouth	Aerial. Mixed, 150, 200, 300 and 400lb. Copper with some 40lb., 150lb., and 200lb. U.G.	Unloaded	—
London—Southampton ...	20lb. Phantoms.	250 mh. at 1.136 miles	2320

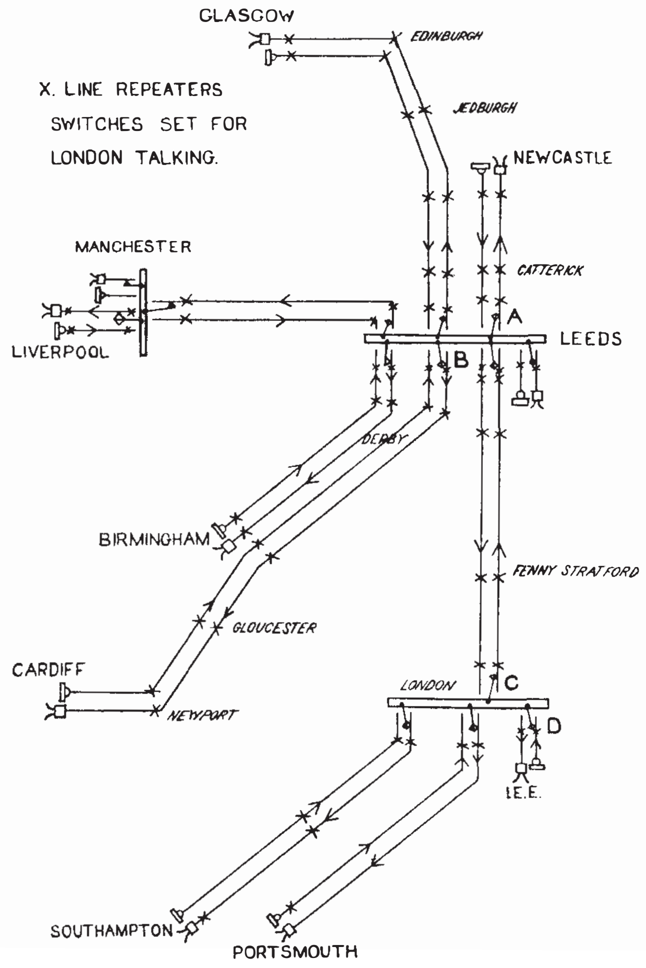

FIG. 3.

The loaded lines, except those to Southampton, were all equalised by the insertion of tuned circuits at suitable repeater stations to give level transmission characteristics from approximately 200 ∿ to 3000 ∿.

Loud-speakers.—Tests made some time previously of a number of various types of loud-speaker had shown that the Amplion Lion type 41 was a very satisfactory instrument with the advantage that no additional polarising current was required, and it was decided to use these. The makers very kindly offered to lend as many as might be required and in fact did supply 26. These were allotted as follows:—Four in the Lecture Hall at Savoy Place, two in the Library there, one in the tea room and two at each of the local centres. A three stage amplifier was provided for each station with arrangements for cutting out one stage if required. A potentiometer was provided on the input in each case to serve as a volume control, but no tone control was fitted. 300 volts in W size dry cells were used at each local station, and 400 from accumulators in London. Provision was made for two LS5A type valves (not shown in figure) in the last stage at each local station.

Fig. **4** shows the amplifier circuits for the local centres.

At the London end the conditions were rather more elaborate. Provision was made for two

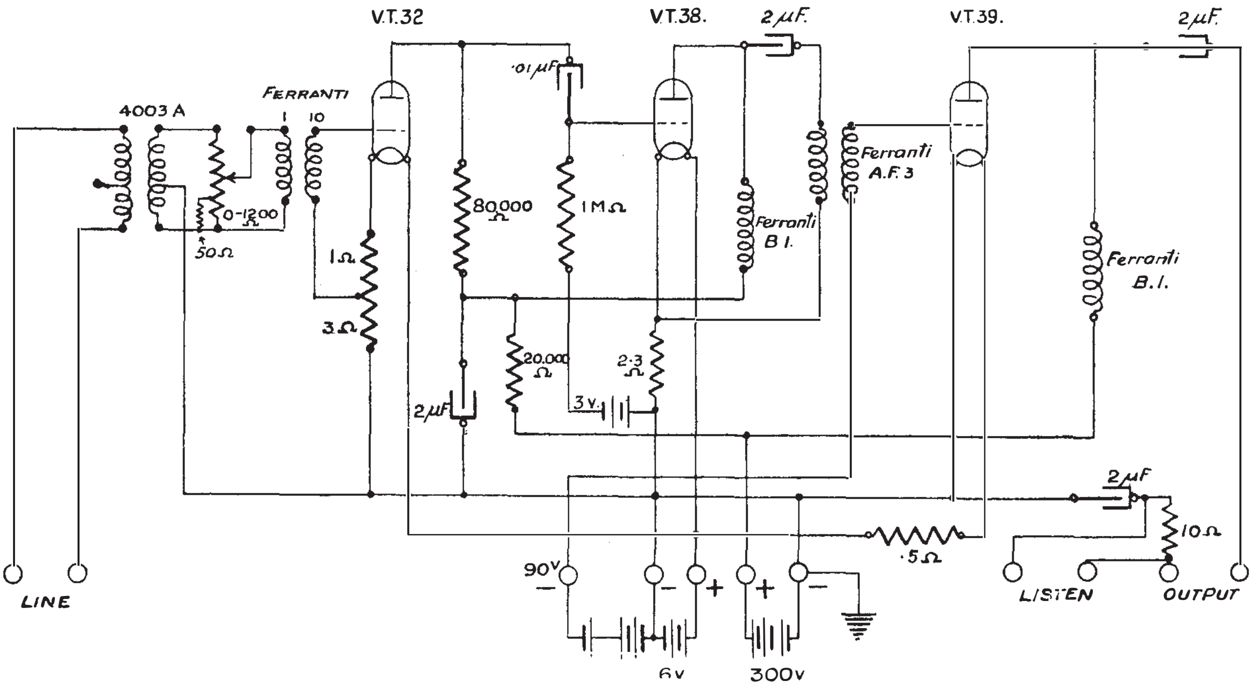

FIG. 4.

overflow meetings to receive all speeches from all stations if required. A line plan of the arrangements is shown in Fig. **5** and the circuit details in Fig. **6**. Provision was made (not

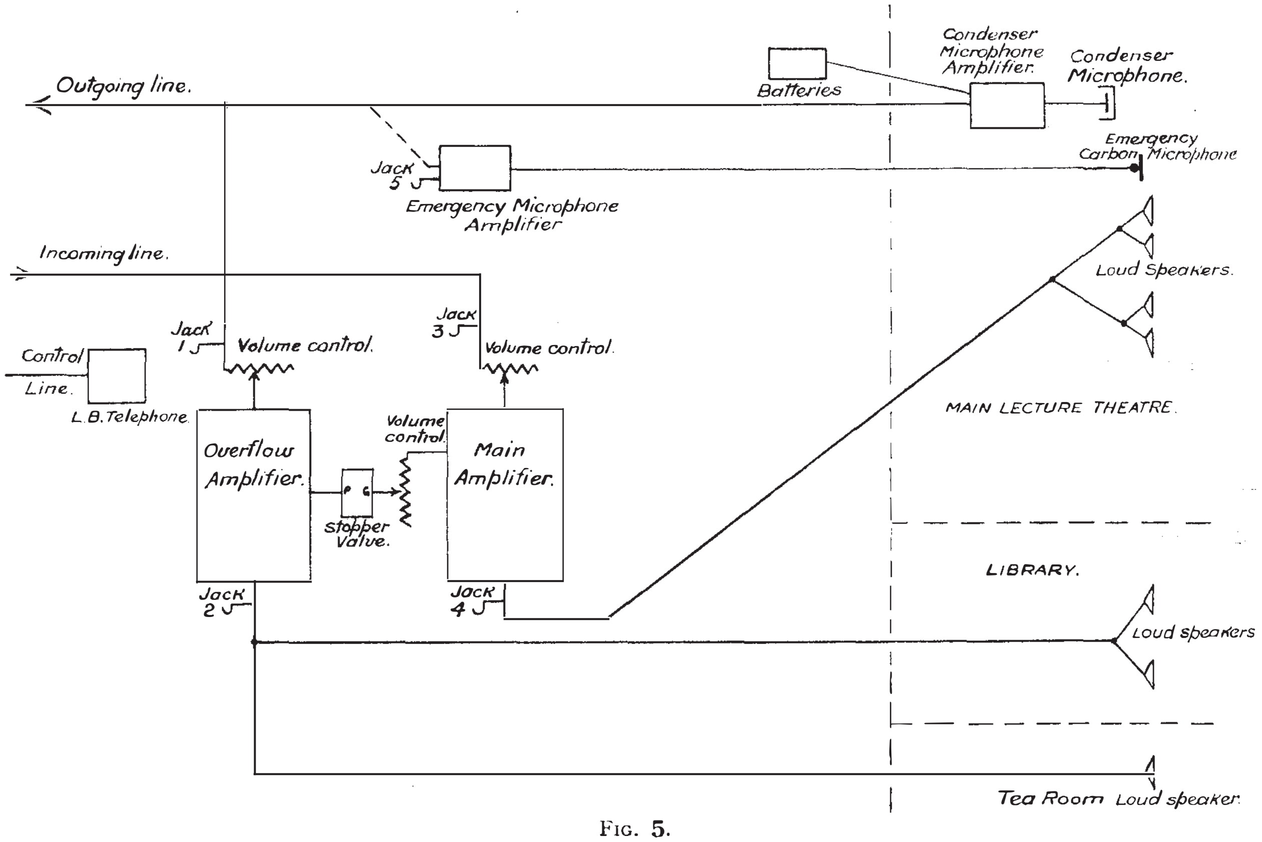

FIG. 5.

shown in Fig. **6**) for four valves in parallel in the output stage, but only two were actually used. Reference to Fig. **5** will show that the overflow meetings obtain the President's address *via* the overflow amplifier. They receive the local stations *via* part of the main amplifier, stopper valve, and part of the overflow amplifier. The stopper valve prevents the President's address appearing in the loud-speakers in the hall in which he is speaking.

to distribute the sound beams (fairly pronounced at the higher frequencies) over the lecture room. A rehearsal was held on Thursday afternoon to ensure that all was in order and to enable final adjustments to be made and familiarise all concerned with the procedure to be adopted. An attempt was also made at this time to adjust the volume levels from the different stations. The whole of the operations were controlled at the actual meeting by the President in London.

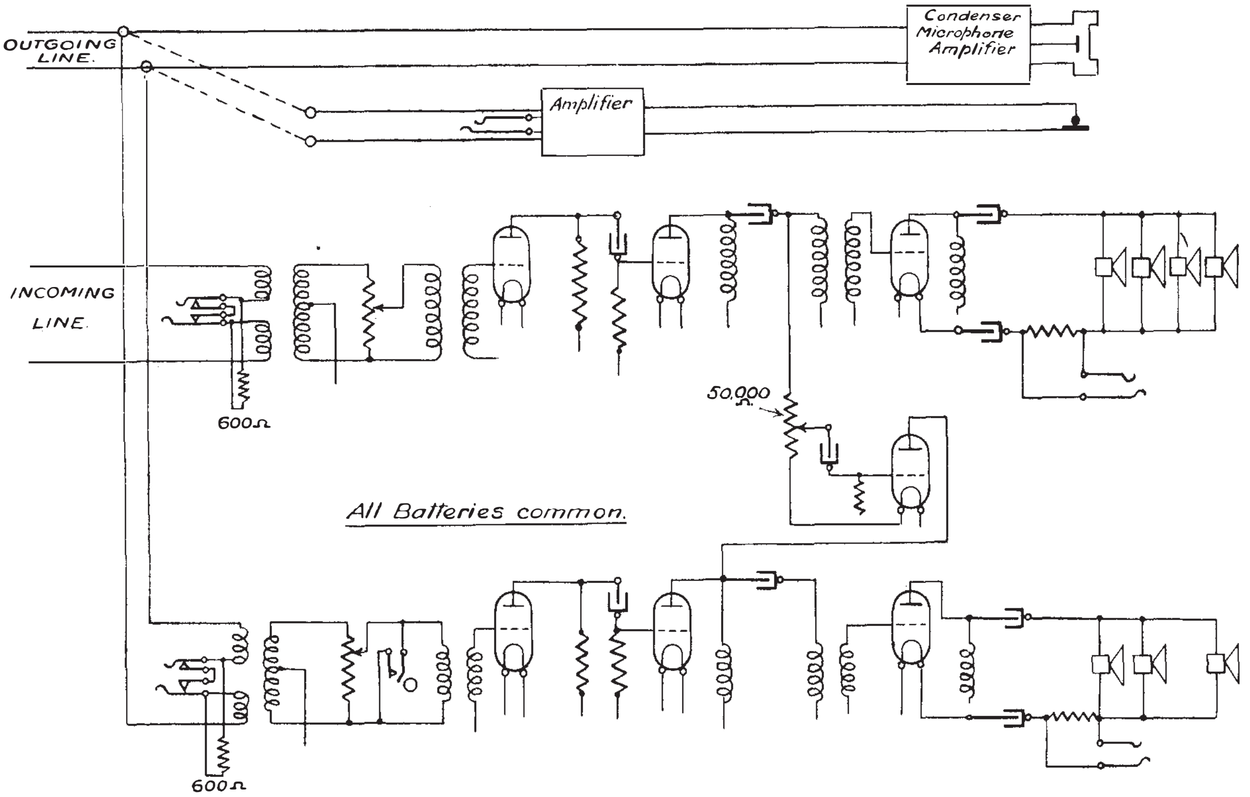

Fig. **6.**

Monitoring at each receiving station was carried out by listening across a small resistance in the loud-speaker circuit.

General Arrangements.—The inspectors in charge at the local stations were given a demonstration of the apparatus at Dollis Hill. The apparatus for each station was then dispatched so that preliminary trials could be made locally as to the best disposition of the loud-speakers and so that the officers could familiarise themselves with the arrangements. In London the only convenient place for the loud-speakers was over the doorways on either side behind the President's chair. These were arranged so as While he was speaking the London microphone circuit was commoned to all the other loud-speaker circuits, the remaining microphone circuits being disconnected as shown in Fig. **3**. The President then, for example, called over all circuits upon Newcastle to indicate if they were in session. Keys A and B were thrown by the Leeds control officer and C and D by the London control officer. Newcastle was then in a position to speak to all stations. Immediately he had finished the keys were thrown for " London talking " and the procedure repeated with each station in turn. The arrangement was found to work quite satisfactorily.

Remarks.—The general opinion obtained both from observers in London and the local centres was that the broadcast was a distinct success. Reception appears to have been good at all places except when Glasgow was transmitting. The speech from Manchester was received extremely well at all stations and Birmingham reported "Reception exceptionally good." Some difficulty was experienced at Portsmouth due to the rather awkward room, but this was reduced by the provision of two additional loud-speakers and the draping of the room. The articulation at Southampton was not as good as was desired, but this was due to the unavoidable use of unloaded U/G circuits. The reception of the President's address in the overflow meetings in London was very natural and better than that obtained in some parts of the Lecture Hall itself. Probably the chief defect of the demonstration was the variation in volume level from the various centres. A volume control was fitted on each loud-speaker amplifier, but most of the centres were not transmitting for a sufficient length of time for it to be very effectively used. The preliminary adjustment, made during rehearsal, though helpful, could not be very definite, especially at the local centres. To have ensured a definite and uniform level would have necessitated a considerable increase in the local equipment and more time than was available in regulating the transmission levels over each part of the system.

It may be of interest to state about 2,000 miles of circuit were used, 62 line repeaters and 22 local amplifiers.

SOUTH MIDLAND CENTRE, I.E.E.

The annual dinner was held at the Grand Hotel, Birmingham, on 29th November, 1929, and was presided over by Mr. G. R. J. Parkinson, Chairman of the Centre. Mr. Neville Chamberlain, M.P., Col. Sir T. F. Purves, President of the Institution, and Sir Andrew Duncan, Chairman of the Central Electricity Board, were the principal speakers. The function was very well attended, the Grosvenor Room of the Grand Hotel being filled to capacity.

In addition to the presence of the Engineer-in-Chief as President of the Institution, the P.O. Engineering Staff of the North Wales District was represented by the Superintending Engineer, two Assstant Superintending Engineers, and five Executive Engineers.

The speeches have been fully reported in other Journals, but it is worthy of note that the I.P.O.E.E. members participate fully in the various I.E.E. functions at Birmingham. The re-union which took place after the dinner afforded a welcome opportunitv of fraternising with members of other branches of the electrical industry who are met in the ordinary course of official business. Occasions of this kind give the Department's representatives an excellent opportunity of enhancing the prestige of the Post Office Engineering Department and full advantage of the occasion was taken.

NORTH-WEST CENTRE, I.E.E.

On the 22nd October, Mr. T. E. Herbert (Asst. Superintending Engineer, South Lancashire District) delivered his address as Chairman of the Centre at the inaugural meeting of the Session. After sketching the history of "Inland Telegraphs," there followed a suggestion as to the possible trend of development in the direction of automatic switching, thereby enabling many communications now sent by post to be typed direct to the recipient's office.

The address was illustrated by working circuits: (i) Teleprinter 3A; (ii) Full Wheatstone; (iii) Creed Keyboard Perforator, Receiving Perforator and Printer; (iv) The Mendonça Baudot.

On the 29th October, Mr. T. E. Herbert addressed the Students' Section on the subject of "Recent Advances in Submarine Telegraphy." Special attention was devoted to the use of regenerative repeaters used in connection with multiplex circuits on trans-Atlantic cables

—a development rendered possible by the use of thermionic valves for reception on loaded cables.

The Annual Dinner of the Centre took place on the 19th November, the guests including the President, Col. Sir Thomas F. Purves, Lord Colwyn, Dr. S. Z. de Ferranti, Dr. Daniel Adamson, President of the Institution of Mechanical Engineers. The toast of the Institution was proposed by Lord Colwyn, who pointed out that the electrical industry was equally concerned with all others in the great problems with which the country was now face to face. The young men in electrical engineering were equipped with brain power and other qualities of mind suited to play their part in solving these problems. He issued an emphatic warning against financial speculation, since it served neither the country nor did it bring honour to the participants, whereas honest work did both.

In reply to the toast, Sir Thomas first expressed his pleasure in meeting such a magnificent assembly (close on 300 sat down to dinner) in Manchester honourably associated with the industry, art, science and thought of England. Each Centre of the Institution had its individual life and power to act independently of the parent body, but all were united to bring their collective wisdom to bear upon the problems which presented themselves. He was doubly pleased to be present, because the Centre was presided over by an old friend and colleague and because it was the most virile and active of all the Centres.

The toast of the guests was proposed by the Chairman. Mr. T. E. Herbert said that this year, as always, the Centre had been honoured by the presence of many learned and distinguished guests whom they were delighted to honour.

NORTH-EAST CENTRE, I.E.E.

The annual dinner and re-union of the members of the North-East Centre was held at the Station Hotel, Newcastle-upon-Tyne, on the 3rd ult., and was attended by the Civic dignitaries and many prominent men in mining, shipbuilding and engineering circles. The Post Office Engineering Department was strongly represented and included Col. Sir T. F. Purves (the President of the Institution), Mr. J. R. M. Elliott, Superintending Engineer, and Mr. F. G. C. Baldwin, Assistant Superintending Engineer, who is a past chairman of the local centre. Mr. J. R. Andrews (P.O. Engineer), Chairman of the Freemen of Newcastle-upon-Tyne, and for some years Honorary Secretary of the local Institution Centre, proposed the toast of the Lord Mayor and Corporation in a felicitous speech, in which he paid tribute to the Corporation and its work, and in particular to their able assistance in the ready granting of wayleave facilities in Newcastle and help in other directions which was much appreciated by the Post Office.

The Deputy Lord Mayor and Sheriff suitably responded.

Professor Henry Louis, President of the Iron and Steel Institute, proposed the toast of the Institution of Electrical Engineers and said he was keenly sensible of the help the Institution had given to the great industries of the country and to the community at large. He was also glad to have the opportunity of publicly acknowledging the work of its President, which was so important to the country and yet the public scarcely knew of him. Col. Purves, before replying, was the chief spectator of a one-act comedy, the entire company singing "All alone on the telephone" with great gusto. Sir Thomas in the course of his reply said he always felt that much of the best brain and the hardest work of the Institution came from the provincial centres. He considered that one powerful institution embracing all classes of electrical engineers with rationalized organisation was bound to be a far more effective instrument for good than a number of independent electrical societies. On this principle the Institution was striving hard to cater for all classes of electrical engineers throughout the country. The North-East centre brought to the Institution a great deal of technical knowledge and ability, and he was sure that the Tyneside character would show itself with equal effect in the administration of the Institution's affairs.

The proceedings were brightened by many humorous anecdotes and altogether the event was one of the most successful ever held in the North-East Centre.

AN ARTIFICIAL EAR.

W. West, B.A., A.M.I.E.E.

SUMMARY.—A description of the construction and performance of apparatus designed to comply with the specification that the acoustical impedance shall lie within the range of normal variations obtained for real ears. The construction comprises a coupling device associated with a condenser transmitter whose frequency characteristic is not seriously affected thereby. Possibilities are indicated for the use of this apparatus for replacing real ears in transmission measurements.

1. In a large number of investigations in connection with telephone transmission testing, a need has been felt for a mechanical or electrical device which can be used for recording the sound pressures developed by a telephone receiver when in use under its working conditions, *i.e.*, when held to an ear. Such a device, or "artificial ear," should offer, to an applied telephone receiver, an acoustical impedance substantially equivalent to that of a normal real ear, and should incorporate sound measuring apparatus whose performance is practically free from distortion.

As a result of a recent investigation,* information is available of the magnitudes of acoustical impedances liable to be encountered on normal ears over a considerable range of frequencies. Attempt has not been made to match exactly the acoustical impedance of the artificial ear to the mean impedance found for real ears at all frequencies, since it is thought that it will be sufficient to provide an impedance lying within the normal range of variation at all frequencies. Experience with high quality sound detectors led to the selection of a condenser transmitter for incorporation in the artificial ear.

The problem of design therefore consists in the construction of a coupling device, between a telephone receiver and the condenser transmitter, which shall present a suitable acoustical impedance to the receiver, and at the same time shall not seriously impair the frequency characteristic of the condenser transmitter. Experience has shown that a coupling device of the kind originally accepted for use for calibrating the International Reference Standard Receiver is unsatisfactory, owing to the formation of an acoustical resonator in front of the diaphragm of the condenser transmitter.

It has been observed that the acoustical resistance of a semi-infinite rigid walled tube of about $\frac{1}{4}$ inch internal diameter provides a good match to that of a real ear. The construction of the artificial ear to be described makes use of such a tube for providing the necessary dissipation of sound energy, some lack of rigidity in the wall of the tube being permitted locally for operating the condenser transmitter.

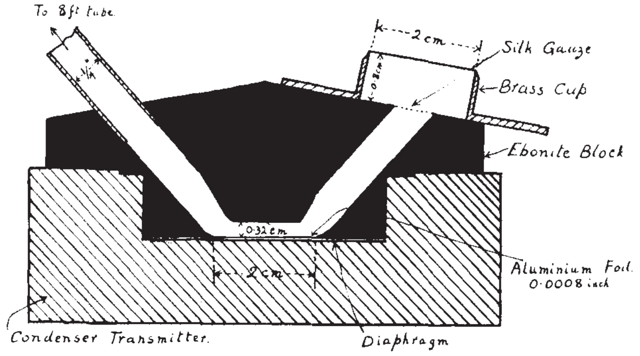

Fig. 1.

2. *Constructional Details.* — The essential details are shown in Fig. 1, which illustrates an elevation cross-section through the coupling device in position on a condenser transmitter. A block of ebonite was made to fit closely over the diaphragm of the transmitter. In the centre of the block, immediately over the diaphragm, a groove, 2 cm. long by 1 cm. wide and about 0.32 cm. deep, was cut, and two $\frac{1}{4}$ inch diameter holes were bored outwards from the ends of the groove to the sides of the block. At the junctions with the groove the passage was shaped so that the cross-sectional area remained practically constant. At the base of the block, covering the groove, a sheet of thin (0.0008 inch) aluminium

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* *See previous article in this Journal, Vol. 21, Part 4, January, 1929, p. 293.*

foil was stretched and cemented to the block. At one end the passage was continued into an 8 ft. length of $\frac{1}{4}$ inch diameter (nominal) lead composition tube which was coiled, on a 9 inch diameter, round the condenser transmitter; to the far end of this tube was drawn a bundle of 10 strands of darning wool in the manner and for the purpose stated in the reference cited above. The other end of the passage was covered with a dust screen of silk gauze and surrounded by a short brass cylinder forming a cup 2 cm. in diameter and 0.8 cm. deep. The rim of this cup was cut to a knife edge, and the transmitter was mounted at a slight angle on a base board so that the rim lay in a horizontal plane. A telephone receiver is simply placed over the cup, generally an air seal is ensured by the application of a little plasticine or mineral jelly at the rim. The ebonite block is secured in position on the transmitter and suitable arrangements for the electrical connection of the transmitter to an amplifier are provided on the base board. The exact dimension of the gap between the aluminium foil at the base of the block and the diaphragm of the transmitter cannot be stated; it is, however, known to be less than 0.005 inch.

3. *Performance.*—The artificial ear has been tested for acoustical resistance and reactance and for frequency characteristic; it has also been substituted for real ears in a volume efficiency test of standard C.B. transmitters.

(*a*) *Acoustical Resistance.*—The method employed for carrying out these measurements has already been described.* A stationary wave method is used, the acoustical impedance under test being applied at one end of a tube, 2.75 inches in diameter, and comparison is made between the sound pressures generated in the tube when terminated by this impedance, and by certain acoustical resistances of known values. This apparatus has been in use for the measurement of the sound absorbing properties of materials, and the extended use has necessitated some modifications. The rubber seal between the cork piston of the driving unit and the tube has been replaced by one of 0.01 inch thick sheet lead, and the condenser transmitter has been transferred to the driving end of the tube, where a slit of 0.5 by 0.05 cm. is provided in the wall of the tube. Table I. shows the acoustical resistance found for the artificial ear, together with the range of resistances found for normal ears, reproduced from the previous article.

TABLE I.

Frequency (Cycles per sec.)	Resistence of Artificial Ear.	Extreme resistences of real ears.
370	106	100—300
745	102	90—350
1100	111	105—190
1500		80—145
1670	111	—
2600	72	13—125

The theoretical resistance of a $\frac{1}{4}$ inch tube is about 130; it will be observed that the coupling device of the artificial ear exerts a somewhat greater absorption than that of a simple tube. Although the resistance of the artificial ear lies within the range of normal variation for real ears at all frequencies it is below the mean value at lower frequencies and above the mean at the higher frequencies.

(*b*) *Acoustical Reactance.*—For this measurement advantage was taken of the sound measuring apparatus, forming part of the artificial ear, to measure the resonant frequencies of Bell type receivers having diaphragms of different constructions; comparison was made with the resonant frequencies observed with the same receivers held to the known variable reactance which has been described in the previous article. The results, reduced to terms of the equivalent volume of the reactance, are shown in Table II., together with the range of variation for normal ears.

TABLE II.

Frequency (Cycles per sec.)	Equivalent Volume of artificial ear. (C.C.)	Range of equivt. volume of real ears (C.C.)
500	3.1	+ 4.0 to − 4.0
1100	2.7	+ 5.0 to + 1.0
1600	2.5	+ 5.0 to + 2.0

The actual volume of the cavity is about 2.5 cc. It is not certain whether the somewhat larger value observed at the lowest frequency is attributable to experimental error or not.

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* *loc. cit.*

(*c*) *Frequency Characteristic.*—It was required to know the performance of the instrument in terms of the ratio of the e.m.f. generated by the transmitter to the sound pressures on the "outer ear." The calibration was therefore effected by means of a Rayleigh disc mounted in a tube, one end of which was closed by the artificial ear and the other end by a source of sound. This method gives results applicable to working conditions provided that the change of acoustical impedance, as between the resonating tube (non-reactive) and the receiver in position on the ear (elastic reactance), does not appreciably affect the performance of the transmitter.

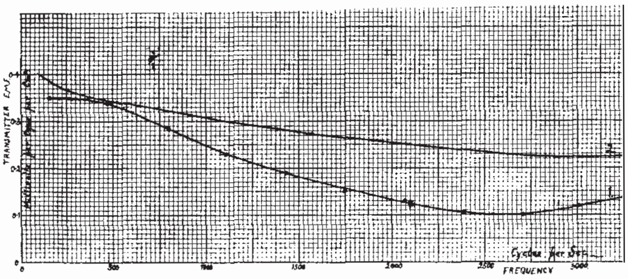


FIG. 2.

Curve 1 of Fig. 2 shows the frequency characteristic of the artificial ear, and Curve 2 shows that of the same transmitter (No. 111, type 370 W) taken in terms of pressures on the diaphragm, before attachment to the artificial ear. In an attachment of this kind, care is necessary to ensure that the small air chamber formed over the diaphragm of the transmitter does not act in conjunction with the foil at the base of the coupling device (or with the mass of the air in the passage if the foil is omitted) to form a resonator. For this reason the air gap should be very small, so that the acoustical resistance, imposed by lateral motion of the air between two surfaces close together, provides sufficient damping. If the thickness of the air gap is increased, a resonant peak may therefore appear in the frequency characteristic of the artificial ear. The presence of such a peak is liable to introduce error, due to the fact that its position on the frequency scale may be appreciably altered by a change of acoustical load on the artificial ear.

The curve for the artificial ear shows evidence of sufficient damping to reduce any effect due to the change of acoustical impedance to negligible proportions.

As it stands, the curve shows that variations of sensitivity with frequency do not exceed 3.5 to 1, which is a reasonable figure for acoustical apparatus. Since, moreover, the curve is a smooth one, a simple modification of the amplifier following the transmitter will suffice to compensate for the irregularity by reducing the sensitivity at the lower frequencies. A further reduction at the lower frequencies would be necessary in order to simulate the frequency sensitivity of a normal real ear (vide Fletcher and Wegel, Physical Review, 1922, Vol. 19, p. 553). For transmission measurements of sounds of speech it is probably unnecessary to consider frequencies above, say, 3,000 cycles per sec.

(*d*) *On Transmission Testing Circuit.*—The artificial ear was substituted for a real ear in an efficiency test of 12 Research Section Standard C.B. transmitters on the usual transmission testing circuit. The condenser transmitter of the artificial ear was connected through a three stage amplifier to a volume measuring set provided with an instrument calibrated to read directly in terms of standard miles of cable. A set of this kind has been described in an earlier number of this Journal (A. J. Aldridge and A. Hudson, "A Method for the Measurement of the Transmission Efficiency of Telephone Apparatus at a Subscribers' Office," Vol. 17, Part 2, July, 1924). The transmitters were tested in pairs, each of three speakers giving alternately from 3 to 5 consecutive counts of "one—two—three—four—five" on each transmitter. The artificial ear is far more sensitive to changes of volume than a real ear, and the chief difficulty of the test was due to variations in intensity of speech of which the speakers were unaware. It was frequently observed that the intensity varied considerably during a series of counts on a single transmitter; in such cases no reading was recorded.

The results are summarised in Table III. together with the corresponding figures (quoted in the last column) obtained from the stated transmission efficiencies of the transmitters at the time of the test. The agreement is seen to be very close for a test of this kind.

Table III.

Transmitter A	Transmitter B	Receiver.	(A—B) Transmission Efficiencies in S.M.	
			On Artificial Ear Set.	By Standard Method
B 13	R.S. 99	R.S. 80	4.0	5.0
B 10	,, 24		4.0	3.2
RS114	,, 104		2.0	2.0
B 11	,, 5		1.0	1.6
B 20	,, 80		1.5	1.0
B 16	,, 14		0	0.1
B 14	,, 80		1.5	0.8
	,, 5		0	0.5
	,, 104		1.0	0.5
	,, 24	R.S. 78	1.0	1.4
	,, 99		1.5	2.3
	B 16		1.0	−0.1
	B 20		1.0	−0.5
	B 11		0	−1.0
	R.S.114		−1.0	−1.5
	B 10		−2.0	−2.0
	R.S. 13		−2.5	−2.5

4. *Possible uses of an Artificial Ear.*—For measurements, in absolute units, of the performance of receivers under their working conditions, an artificial ear is almost essential. Such a device has already been used to measure the sound pressures developed, for a given electrical input to the receiver, for speech and single frequency currents. An artificial ear would also be required for carrying out a more extensive investigation of the performance of receivers when held to the ear, to include for example the nature and extent of any non-linear and transient distortions. Measurements of this kind on a receiver have hitherto suffered neglect, since these types of distortion are probably less serious in the receiver than in the existing patterns of carbon granule transmitter; this, however, may not always be the case.

An artificial ear has, however, other and perhaps more important possibilities in replacing real ears for volume measurements of telephone transmission. The tests recorded in paragraph (*d*) of the previous section indicate possibilities in this direction, but the full technique of transmission testing by artificial ear has yet to be developed and proved. In this connection it is advisable to differentiate between comparisons of circuits or instruments without and with appreciable tone difference. When there is no tone difference the real ear provides an accurate relative comparison between different conditions of circuit or instrument; it provides, however, no permanent record that is not dependent on the reproduceability of the performance of the standard circuits and instruments. As the tone difference increases, wider discrepancies between results with different observers necessitate a larger number of tests and observers in order to obtain a representative average. Under these circumstances, the elimination of personal bias by the use of an artificial ear becomes more important. It should be noted that the test results recorded above refer to the condition of no appreciable tone difference, and that no modifications of the existing frequency characteristic of the artificial ear were made. It is probable that, for tests with tone difference, it will be necessary to adjust the frequency characteristic (*e.g.*, in the amplifier of the condenser transmitter) to conform approximately with that of a normal ear. If, as a result of experience, it is found that a measurement by artificial ear suffices to differentiate between the relative volumes of speech on different circuits, then, by eliminating distortion from one of the circuits, it will be possible to measure the volume efficiency of a distorting circuit in absolute units—obtained from a calibration of the distortionless circuit.

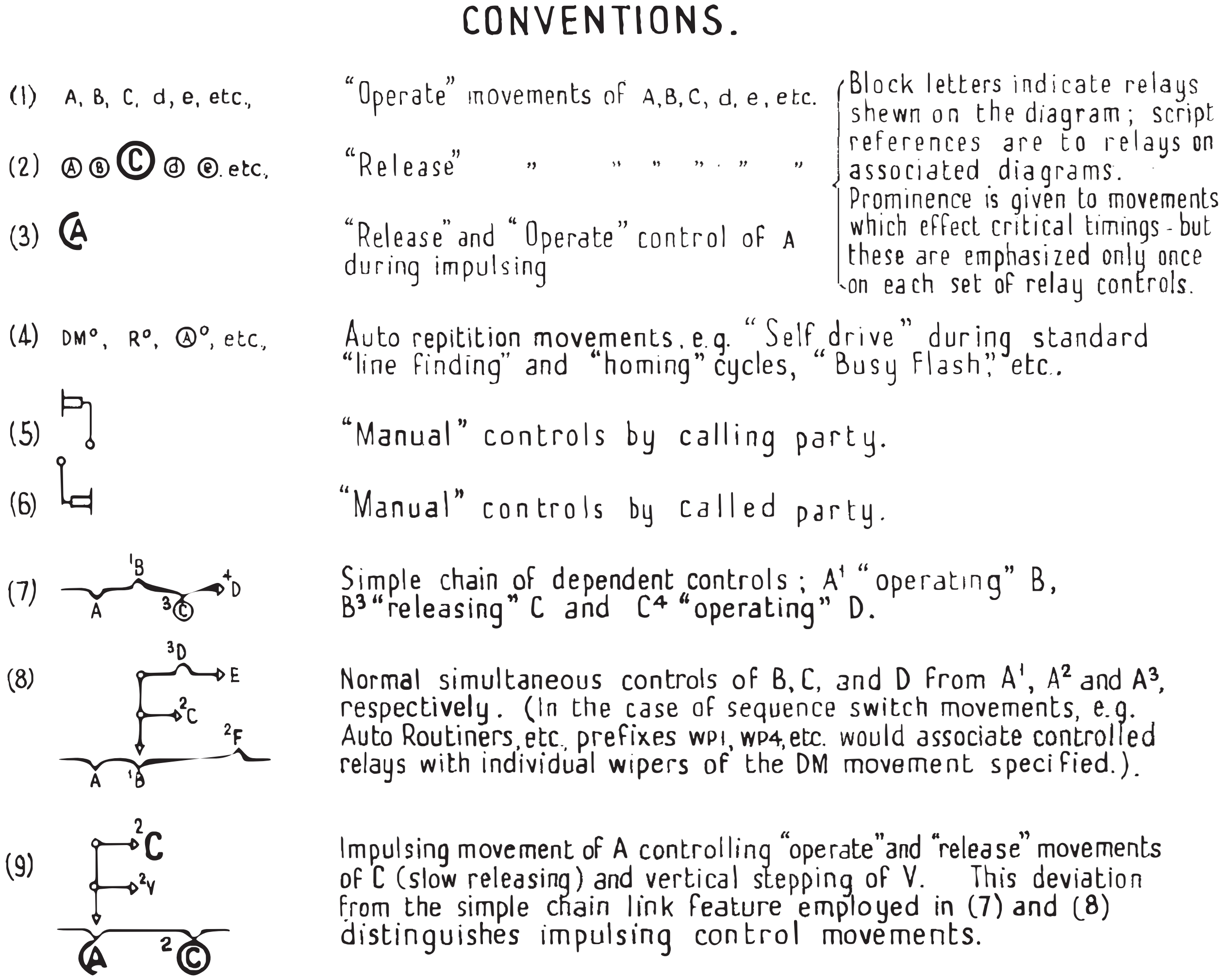
The replacement of real ears by an artificial ear in transmission testing, if practicable, should result in a considerable saving of testing time. Variations necessitating repeat tests will, however, still exist unless more definite control is exercised on the intensity of the source of sound, which is at present the human voice. Such control might take the form of a suitably placed volume indicator, or alternatively the human voice might be replaced by an essentially equivalent mechanically or electrically operated source of sound. The latter alternative is probably the more desirable from the point of view of convenience in carrying out the tests.

CIRCUIT DIAGRAM STUDIES.

W. WHEELER.

THE intricacies of modern telephone circuits and the considerable staffs regularly using diagrams on maintenance, installation, and development work have often impressed the writer as forming a subject on which economy in time and mental effort might be combined with greater efficiency provided circuit diagrams could be made self-explanatory with regard to movement controls and timings. Hitherto, efforts to improve efficiency appear to have been mainly directed towards depicting circuit connections as simply as possible, so that given some knowledge of the results to be achieved readers may be enabled to ascertain working details of the different interdependent controls by careful examination of the circuit connections.

Failures to memorise many of the innumerable details associated with circuits (together with maintenance duties in which circuit considerations play a minor but necessary part) have often created a hostile attitude towards present day methods which impose considerable memory tests upon officers of all ranks—presenting problems which might perhaps be considered as comparable in some degree with those of the cross-word type. Repeated attempts to analyse


CONVENTIONS.

(1) A, B, C, d, e, etc., "Operate" movements of A, B, C, d, e, etc.

(2) Ⓐ Ⓑ Ⓒ ⓓ ⓔ. etc., "Release" " " " " " "

(3) Ⓐ "Release" and "Operate" control of A during impulsing

Block letters indicate relays shewn on the diagram; script references are to relays on associated diagrams. Prominence is given to movements which effect critical timings - but these are emphasized only once on each set of relay controls.

(4) DM°, R°, Ⓐ°, etc., Auto repitition movements, e.g. "Self drive" during standard "line finding" and "homing" cycles, "Busy Flash", etc.,

(5) "Manual" controls by calling party.

(6) "Manual" controls by called party.

(7) Simple chain of dependent controls; A¹ "operating" B, B³ "releasing" C and C⁴ "operating" D.

(8) Normal simultaneous controls of B, C, and D from A¹, A² and A³, respectively. (In the case of sequence switch movements, e.g. Auto Routiners, etc., prefixes WP1, WP4, etc. would associate controlled relays with individual wipers of the DM movement specified.).

(9) Impulsing movement of A controlling "operate" and "release" movements of C (slow releasing) and vertical stepping of V. This deviation from the simple chain link feature employed in (7) and (8) distinguishes impulsing control movements.

FIG. 1.

the fundamental causes of these difficulties have led, a step at a time, to the development of a scheme which promises an easy, effective and uniform method of approach to these cases. Readers may find an interest in a perusal of the ground covered in these endeavours towards simplification—all attempts which can stimulate effective interest in the cause of simplification must make for progress.

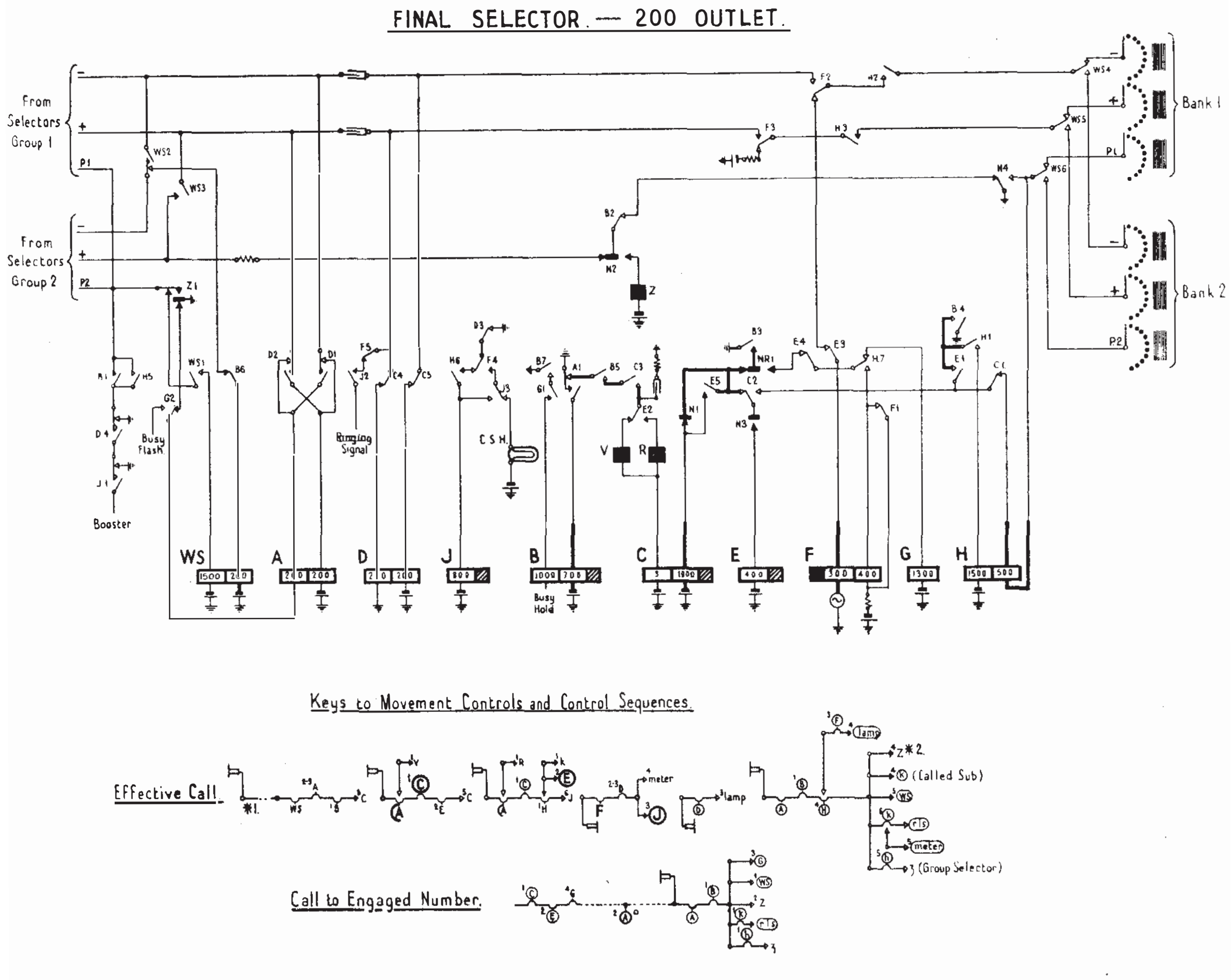
Diagram studies usually resolve themselves into threading one's way through chains of relay and magnet movements, in which process memory and skill combine in endeavours to get a correct appreciation of each function performed in the various chains of auto and manual-auto movements. Much time is often spent in locating detached contacts (which, together with relay coils, are uniformly distributed about the diagram) these searches interrupting the continuity of efforts to get a complete mental picture of all features. A more efficient method would be to employ records which detail in concise terms and correct sequence all movements and controls. Employing such aids and consistently working from the " supply " side (*i.e.*, battery or earth) of each relay, magnet coil, or lamp, towards given " direct control " contacts one is able to make accurate and rapid progress through a circuit. To the writer's mind the simplest way of depicting controls and sequences would be by the employment of graphs or key diagrams on the circuit connection diagrams. Such records of causes and effects would be analagous to moving pictures (" moving " at one's own speed and available when wanted) in which authoritative records of individual controls could be examined as desired with a mind freed from the need for determining the designers' sequences and from consideration of preceding control links.

There is sometimes difficulty in gaining a clear conception of the critical " timed " controls which operate simultaneously with others; the employment of sequence diagrams seems likely to be of special value in this connection. As will be seen from the specimens given, these diagrams enable a reader's attention to be easily directed to those operating or releasing movements which have to fulfil the " timing " requirements essential to satisfactory functioning. Such pointers would be of value when a proposed circuit is under review—clearly indicating also to the maintenance staffs and to students the weaker or marginal links.

In order to lead up to the point where circuit closing actually takes place, written circuit descriptions are usually punctuated by references to the movements of circuit-preparing contacts. In the scheme suggested, " operating " and " releasing " controls only are quoted, there being no necessity for the majority of purposes to make direct references to the closure of circuit-preparing contacts. In order, however, to enable the features in design to be fully understood at the time a new circuit is being examined, schedules tabulating all the contacts employed might be prepared, brief notes being made against each contact indicating its utility. Such records together with supplementary designing notes based on circuit Laboratory test reports, etc., would doubtless be of value in connection with the consideration of improvements and modifications suggested at a later date.

A list of conventions relating to these proposals together with specimen cases is given. Footnotes relating to the more important control features appear on the specimen diagrams. Some of the points covered by these notes relate to matters which are gradually becoming general information and there may be differences of opinion as to the extent to which detailed notes should appear on all relevant diagrams. In this connection, and bearing in mind the endeavours usually made to memorise the circuit principles generally employed and the significance of the different relay letters, the case of relay " J " in Fig. **5** may be of interest. The releasing time of " J " in Booster Metering Exchanges is generally associated with the period of application of " operate " currents to subscribers' meters. (See Figs. **2** and **4**). The " J " Relay in Fig. **5** connects the Booster battery, but remains locked for the duration of the call. In this instance Relay " B " is disconnected by the operation of " J," the releasing lag of " B " determining the period of application of the metering current. It will probably be remembered that in most Systems " B " relays remain operated until the calling party clears.

It will be seen from the specimen cases given that some variation has been made during the preparation of these diagrams from the lay-out methods more generally employed. The principal feature aimed at has been the giving of prominence to all the main reference points (relay and magnet coils, etc.) involved in detailed examinations of the controls. The connections to the "operate" windings of ordinary 2-coil relays are shown in heavy lines when the windings have different functions.



Ⓐ Impulse "release" periods must fully operate V and R magnets and must not allow relay B to release (Impulses controlling A vary with different "line" characteristics and with the "make" and "break" periods of the dials employed)

Ⓒ Relay C must retain during the "release" periods of Ⓐ

Ⓔ Relay E must retain longer than the maximum "operate" period of H and K relays

F Relay F must function satisfactorily when "trip" and "non-trip" test circuits are connected to the loop

Ⓙ Relay J must retain long enough to provide a margin for the satisfactory operation of Subs meter

*1 The WS (Wiper Steering) Relay is operated on calls made over the "Group 2" Selector Levels only.

*2 The incoming P circuit remains guarded at Z¹, during the period of switch release

Fig. 2.

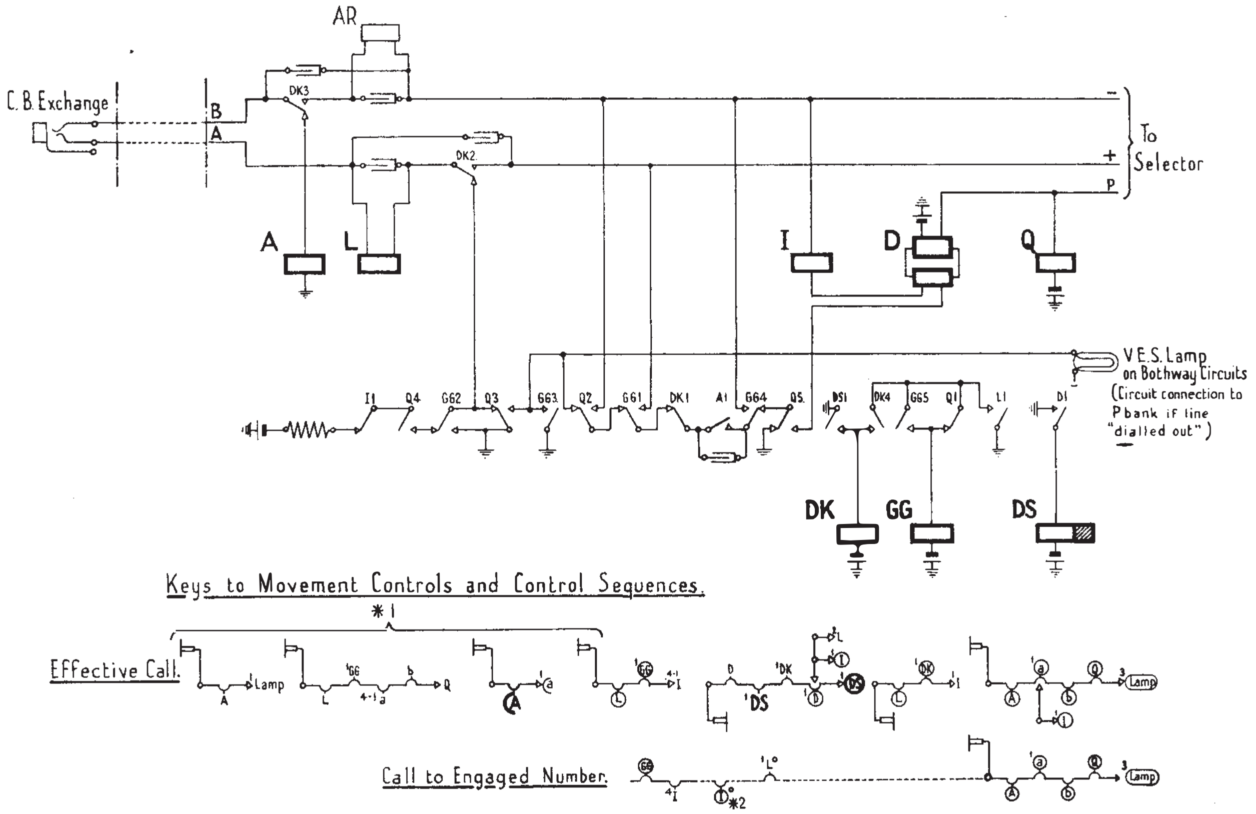
The following notes relate to the different circuits dealt with:—

Fig. **2.** *200 Outlet Final Selector.*—This type of switch affords access to a subscribers' multiple of 200 lines capacity. Double sets of wipers are employed together with a 20-level bank of the standard 10-point type. The addition of a single relay (known as the Wiper Steering relay) furnishes the additional controls necessary. Certain improvements in circuit design are, however, being introduced with this new rank of Switch.

Fig. **3.** *Dialling-in Repeater.*—These repeaters which are in use in a number of Provincial Exchanges link the interests of Manual and Auto Exchange Staffs. This type of repeater is being abandoned, but, as a small collection of relays providing controls which cannot be picked up unaided without a certain amount of study, this case has a certain amount of interest. One "slow" relay only is required.

the outgoing side during impulsing with the application of Earth connections to both wires for other signalling and circuit-holding purposes; this Repeater does not include the Shunt Field type relay found in the majority of cases.

DIALLING IN REPEATER.



Ⓐ Relayed impulse periods must adequately control local and distant selector A relays. (The impulses incoming to A vary with different line characteristics and with the "make" and "break" periods of the dials employed.)

(DS) Relay DS must retain long enough to prevent "Flicking" of DK. The operation of DK releases D which controls DS.

✱1. Four Calling Party controls, viz., "Plug inserted", "Dialling Key operated", "Dialling" and "Key restored."

✱2. Busy Flash Signals transmitted from Final Selector (via I) to the A line.

FIG. 3.

Fig. **4.** *Auto-to-Auto Repeater.*—This circuit will be unfamiliar to the large majority of readers. A point of interest here is the inclusion in one diagram of two features which, although not new in themselves, have not been combined in one circuit hitherto. These features are:—

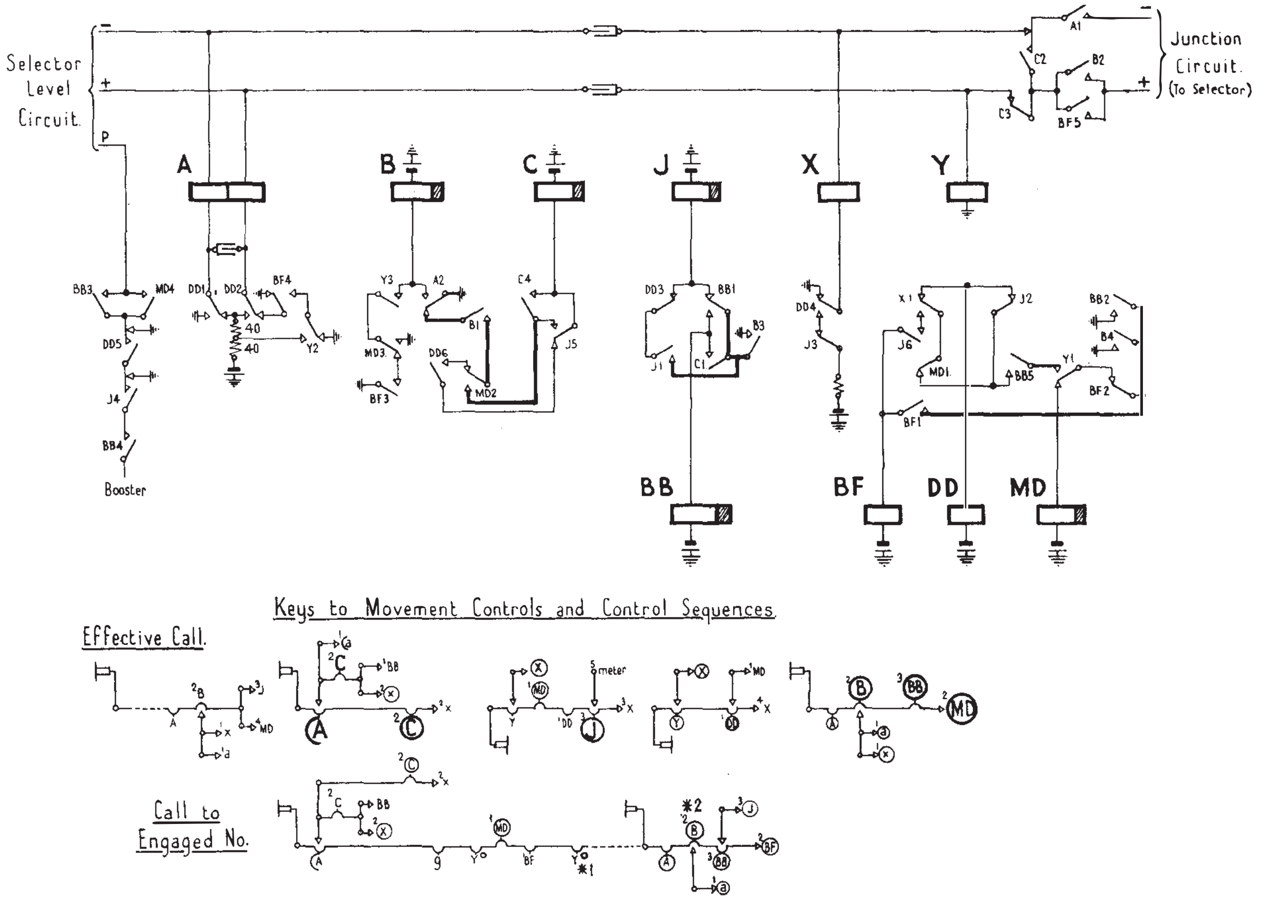
(*a*) The employment of loop conditions on

(*b*) The current reversal is arranged on the supply side of the windings of the A relay, a condenser being bridged across this supply. These features aim at the suppression of clicks.

Fig. **5.** *Satellite-to-Main Auto Repeater.*—This repeater is associated with a Discriminating

Selector scheme and is employed beyond the point in each call where discrimination takes place, only when the call has to be routed *via* the main Exchange. The means of providing "manual hold" facilities are somewhat involved and not very common. Another point of interest is the provision of an "open trunk alarm" facility which causes a calling subscriber to leave the junction engaged (with facilities for his own Auto release) should the external junction circuit be disconnected or short-circuited. Although this facility has been provided in a few areas, the fault liability of junction circuits is not now considered to justify the complication and other costs of standardising this facility.

AUTO TO AUTO REPEATER



Ⓐ Relayed impulse periods must adequately control local and distant selector A relays, whilst retaining B (The impulses incoming to A vary with different line characteristics and with the "make" and "break" periods of the dials employed)

C Relay C must operate on the shortest "release" period relayed by A and retain satisfactorily during the "operate" pulses of A

Ⓙ Relay J must retain long enough to provide a margin for the satisfactory operation of Subs meter

Ⓑ (BB) (MD) Upon "release" the P circuit guard depends upon the aggregated lags of these 3 relays

*1 Flashing is transmitted to the + line by Y2 after BF operates and locks.

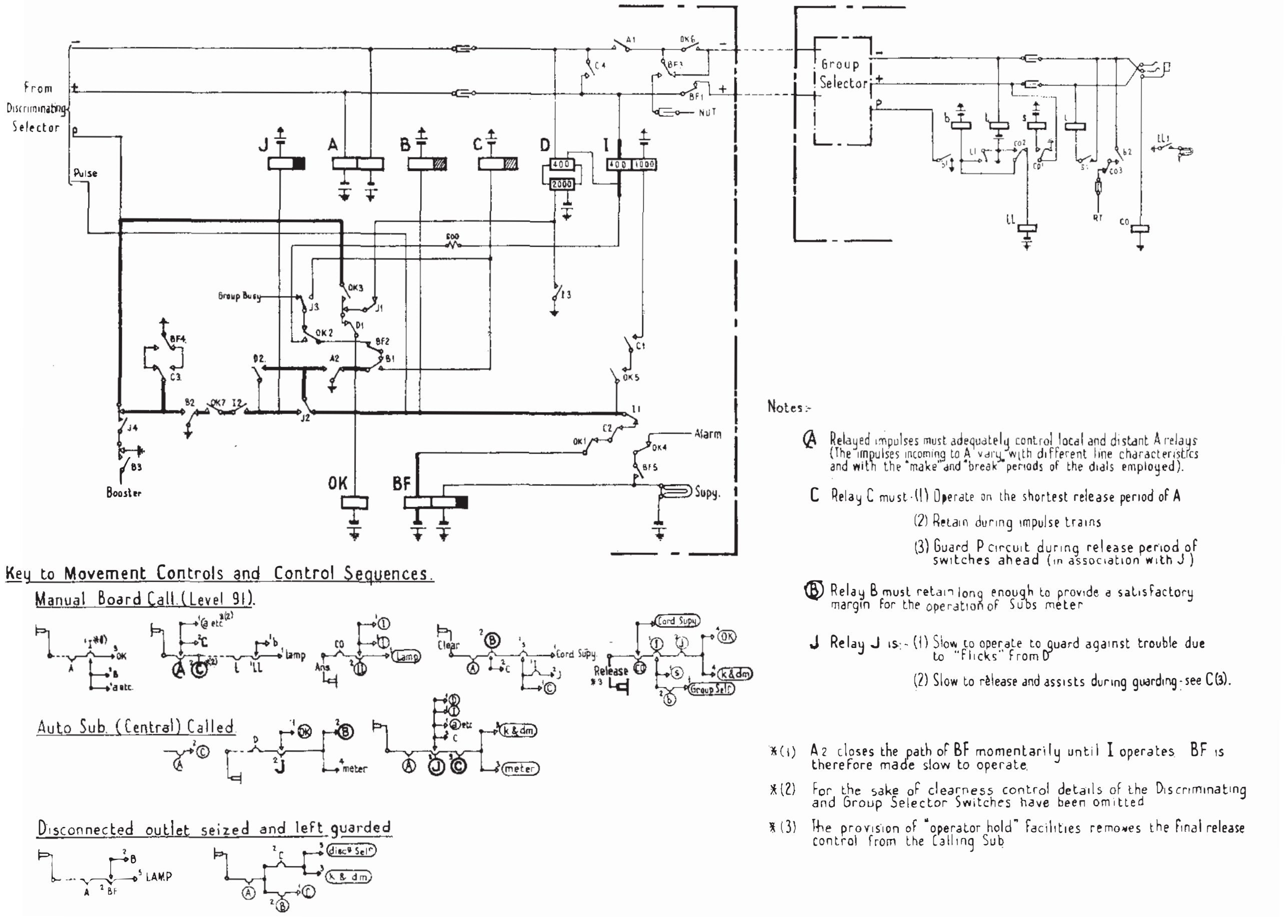
*2 B has retaining paths via Y3 and A2. Release from A2 can therefore be effected only during the periods when Y is de energised

FIG. 4.

Objection has been raised to the scheme on the grounds that circuit diagrams are already overloaded and that any efforts at providing readers with improved facilities would make the work of understanding circuits too easy, resulting in a less complete grasp of detail and a less sound final understanding of circuits. While such an argument may have some value in the case of a few officers whose sole work is connected with circuit design, the author thinks it invalid when applied to the vast majority of officers to whom economy and efficiency in the conduct of fairly large groups appears to depend unnecessarily upon individual intuition. The methods followed in competitive manufacture appear to aim in every practicable way at the elimination from routine work of unnecessary dependance upon individual initiative, in order to set such initiative free for development.

To turn to another aspect of the case, it has been suggested that the methods now proposed are inadequate for the more complicated cases (*e.g.*, Director working), where the setting up of each call involves inter-working between different multi-relay groups. The reply to this is that the case as put forward is believed to furnish a complete framework of principles quite capable of practical adaptation to the most complicated problems. It is not disputed that skill and care may be necessary—careful thought is often neces-

SATELLITE TO MAIN REPEATER


From Discriminating Selector
Pulse
Group Busy
Booster
Alarm
Supy.
Group Selector
J
A
B
C
D
I
OK
BF
Key to Movement Controls and Control Sequences.
Manual Board Call (Level 91).
Auto Sub. (Central) Called
Disconnected outlet seized and left guarded

Notes:-

Ⓐ Relayed impulses must adequately control local and distant A relays (The impulses incoming to A vary with different line characteristics and with the "make" and "break" periods of the dials employed).

C Relay C must - (1) Operate on the shortest release period of A
(2) Retain during impulse trains
(3) Guard P circuit during release period of switches ahead (in association with J)

Ⓑ Relay B must retain long enough to provide a satisfactory margin for the operation of Subs meter

J Relay J is:- (1) Slow to operate to guard against trouble due to "Flicks" from D
(2) Slow to release and assists during guarding - see C(3).

*(1) A2 closes the path of BF momentarily until I operates. BF is therefore made slow to operate.

*(2) For the sake of clearness control details of the Discriminating and Group Selector Switches have been omitted

*(3) The provision of "operator hold" facilities removes the final release control from the Calling Sub

FIG. 5.

circuit considerations represent only one phase of a variety of activities—technical and otherwise. It seems unfortunate that the circuit expert rarely, if ever, gives a lead through the medium of articles in the technical press to show the best method of approach employing existing diagrams, whereby a grasp of these may be within the reach of all without the employment of memory cramming methods. In the absence of such guidance, sary in the efficient presentation of complex cases.

In framing the present proposals, endeavour has been made to attain clearness with regard to main principles, and to avoid an undue amount of application detail. It is believed that undue attention to application details can obscure the value of main principles when men are confronted with proposals which stand in contrast with methods which have been followed for years.

Quite apart from the provision of sufficient space to permit of the inclusion of control details on the front of circuit diagrams it is conceivable that some convention scheme of detailing controls might offer advantages in Maintenance Bulletins, Circuit Laboratory Reports and Journal Articles, etc., over the lengthy written circuit descriptions. Students and teachers might also gain some relaxation from a certain amount of study, hurried note making, and lecture work in class by the employment of simple convention " explanations."

Any complete scheme of Automatic Switching —and the same may be said of many principal sections of such schemes—furnishes a good example of " team " work accomplished by very numerous " members " or team components capable of causing complete failure. In many of the present day circuits different contractors employ different means of accomplishing the same end. In the present writer's view the case for the association with each auto diagram, of a simple authoritative record of the place and control function of each team component is well beyond dispute, provided an acceptable scheme can be developed.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT, AS AT 30TH SEPT., 1929.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
649,664	529	3,968	52,596	122	London	24,964	93,400	2,479,629	106,842
85,166	2,150	21,058	67,971	2,408	S. East	4,053	56,011	235,840	28,575
88,417	4,498	31,560	61,261	3,641	S. West	21,577	14,338	170,173	66,214
70,645	6,329	38,709	63,905	4,478	Eastern	24,644	42,305	146,308	66,625
102,828	8,644	45,161	62,048	4,259	N. Mid.	32,492	56,469	258,911	112,328
86,862	4,828	30,577	76,008	4,310	S. Mid.	12,266	27,423	207,756	84,734
60,963	4,805	29,942	55,951	3,482	S. Wales	6,579	28,264	134,506	70,968
111,379	7,926	26,962	52,766	4,077	N. Wales	13,899	42,147	296,331	60,556
165,951	1,476	15,751	44,346	3,098	S. Lancs.	14,631	81,518	503,262	49,159
97,885	6,212	30,262	48,064	3,682	N. East	13,189	45,516	258,117	74,850
67,516	3,893	23,971	39,651	2,728	N. West	8,588	36,210	174,320	30,186
50,180	2,577	16,138	26,668	2,809	Northern	6,861	20.200	135,431	41,315
22,646	4,541	8,788	13,664	531	Ireland N.	137	2,909	51,148	2,650
69,906	5,412	27,047	39,564	1,273	Scot. East	5,874	15,241	161,541	43,245
92,320	7,238	24,447	44,069	1,077	Scot. West	12,252	26,124	228,249	34,994
1,822,328	71,058	374,341	748,532	41,975	Total	202,006	588,075	5,441,522	873,241
1,793,252	70,880	371,967	736,838	41,538	Figures as at 30th June, 1929.	198,580	561,582	5,348,082	881,136

LONDON AUTOMATIC EXCHANGE SYSTEM: SATELLITE WORKING.

H. Mortimer
(Engineer-in-Chief's Office).

On July 20th, 1929, Satellite working was introduced in the London Automatic Area by the opening of the Maida Vale and Edgware Automatic Exchanges, which form part of a Satellite Scheme in the London area. Hendon and Colindale were opened on 23rd November, and 3rd October respectively.

The parent or main exchange is Maida Vale, the satellite exchanges being Edgware, Hendon and Colindale; Colindale being worked hypothetically on the Hendon equipment until 1932 when Colindale becomes a main exchange. A few particulars concerning each exchange are as follows:—

Exchange.	Multiple Capacity.	Lines transferred at opening.		Contractor.
		Subscribers.	Junctions.	
Maida Vale	7,600	2,115	991	Siemens Bros.
Hendon ...	3,200	1,993	180	Automatic Telephone Manufacturing Co., Ltd.
Colindale ...	1,200	497	251	Automatic Telephone Manufacturing Co., Ltd.
Edgware ...	1,300	748	151	General Electric Co., Ltd.

The following positions have been provided in Maida Vale Automatic Exchange building:—

Positions.	Maida Vale.	Hendon and Colindale.	Edgware.
A	←	* 35	→
B	8	2	1
Monitors	←	1	→

* Includes Supervisors and Service Positions.

As in the usual satellite working for Non-Director Areas the common equipment is situated at the main exchange, in this case in Maida Vale Automatic Exchange; the switching plant at the Satellite exchanges comprising Discriminating Selector Repeaters and Junction Finders, 1st and 2nd Numerical and Final Selector Switches. It will be observed that no A digit, or Director switches are provided at the Satellites, these being fitted at the Main Exchange and are common plant for the whole area.

It should be stated that the D.S.Rs. (see photograph) which are fitted at the Satellite exchanges have been developed by British Post Office engineers, and are now standard both for Director and Non-Director areas. The circuit of the Repeater has been designed to discriminate either on the 1st, 2nd or 3rd digit and to give the usual standard supervision; the rest of the apparatus at the Satellite exchanges is of the standard type used in all exchanges in Director areas.

The trunking arrangements at the Main and Satellite exchanges are somewhat complicated as compared with a Straight Director exchange, therefore it is proposed to briefly explain the routing of the various classes of calls and the reasons for so doing. The straight line trunking diagram for Edgware and Maida Vale should be considered in conjunction with the notes.

Edgware Automatic Exchange.

The routing shown for Edgware can be taken as typical of the other satellite exchange.

It will be observed from a perusal of the diagram that separate groups of Rotary Line Switches and D.S.Rs. are provided for the Main and Barred trunk groups of subscribers respectively, this being necessary so that all calls, other than unit fee calls, can be trapped on the Auto Manual board at Maida Vale, in the case of the Barred Trunk Group.

To avoid transmission losses on calls *via* Toll,

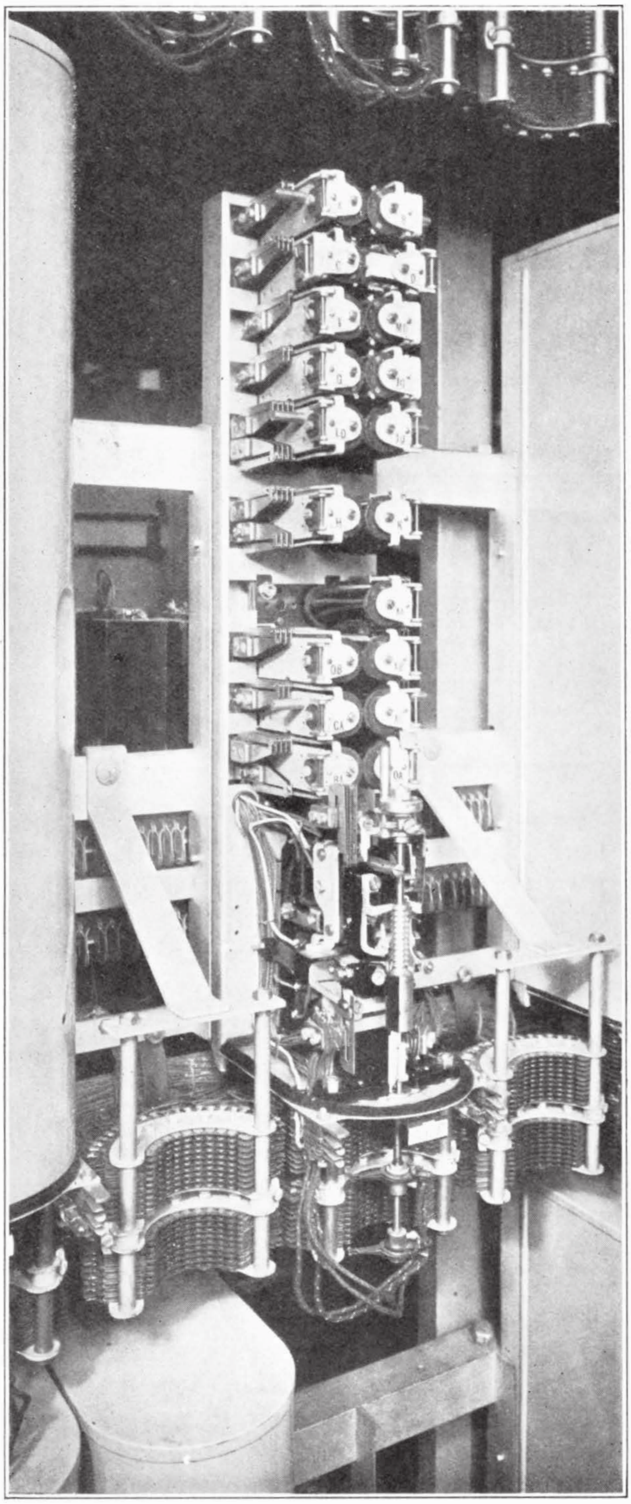


FIG. 1.—DISCRIMINATING SELECTOR REPEATER.

high-grade circuits are provided direct from level 5 of the D.S.Rs., the discrimination taking place after L has been dialled; it is also necessary to provide direct high-grade circuits from O level of the D.S.Rs. of the Barred Trunk Group, so as to avoid transmission losses on calls completed *via* the Auto Manual Board to Toll, etc. It is of course recognised that Coin Box Subscribers can obtain Toll Calls, the fee being collected by the A operator in the Maida Vale Auto Manual Exchange.

Had the Barred Trunk O level calls been routed from a 2nd Code level at Maida Vale, additional transmission losses would have been introduced by the O level calling equipment at Maida Vale.

It will perhaps be convenient at this stage to describe the routes of the various classes of calls from Edgware Auto Exchange (Satellite).

Main Group Subscribers.

(1) *Local Calls.* Assume that the Edgware subscriber requires Edgware 1234. On the calling subscriber lifting the receiver, the Rotary Line Switch seizes a free D.S.R. and also an Incoming 1st Code Switch at Maida Vale *via* a Junction Finder Line Switch. The calling subscriber dials E, and D.S.R. steps up to level 3 and then releases. D is then dialled, the switch steps up to level 3 and again releases, and the same occurs when G is dialled, except that the 4th level is now reached and again released. When the 1 is dialled the D.S.R. now functions as a 1st Numerical Selector and a corresponding 2nd Numerical Selector is seized. The rest of the figures are dialled on to the remaining switches in the usual way.

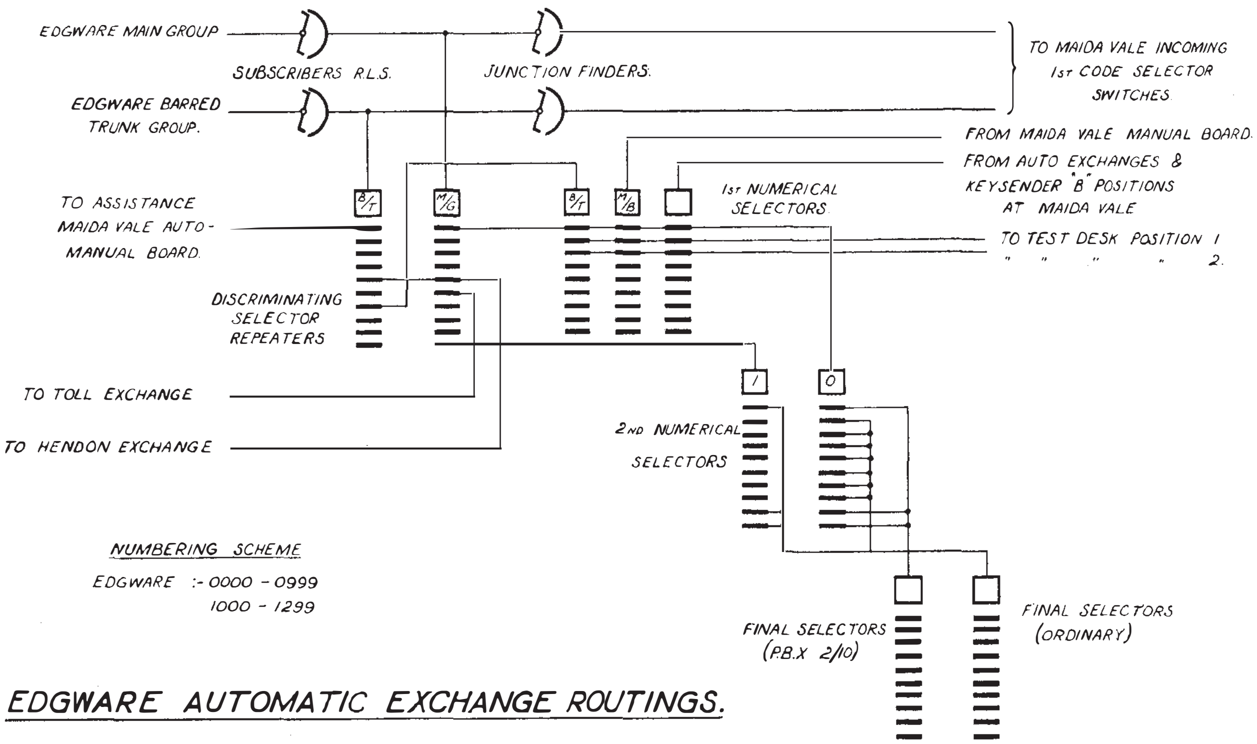
It should be stated that during the time the subscriber is dialling EDG, the A digit and Director switches at Maida Vale will have been operated, but on the discrimination taking place, *i.e.*, after G has been dialled, the junction and switches at Maida Vale are released for further use.

(2) *Toll.* TOL is dialled by the subscriber, and the D.S.R. and the switches at Maida Vale respond similarly to those for a local call. The discrimination takes place on L (5); the junction and switches at Maida Vale are then released, and the caller connected direct to Toll.

(3) *Hendon.* HEN is dialled, and in this case discrimination takes place on N being dialled. The D.S.R. in this case acts as for a local call, *i.e.*, the 4 numerical digits being dialled

on to the 1st, 2nd and Final Selectors Switches at Hendon. Direct junctions are provided between Edgware and Hendon, which terminate on 1st Numerical Selectors in Hendon Automatic Exchange.

(4) *Colindale.* Although the Colindale Equipment is part of the Hendon plant, a call for Colindale from an Edgware or Hendon subscriber has to be routed *via* the main exchange, as it will be seen that the codes TOL and COL are similar. Therefore, as Toll calls are routed direct *via* the D.S.R (level 5) it becomes necessary to route Colindale traffic *via* Maida Vale in a similar manner to a junction call.


EDGWARE MAIN GROUP
SUBSCRIBERS R.L.S.
JUNCTION FINDERS.
EDGWARE BARRED TRUNK GROUP.
TO MAIDA VALE INCOMING 1st CODE SELECTOR SWITCHES
FROM MAIDA VALE MANUAL BOARD.
FROM AUTO EXCHANGES & KEYSENDER "B" POSITIONS AT MAIDA VALE
B/T
M/G
B/T
M/B
1st NUMERICAL SELECTORS
TO ASSISTANCE MAIDA VALE AUTO-MANUAL BOARD.
TO TEST DESK POSITION 1
" " " " 2.
DISCRIMINATING SELECTOR REPEATERS
TO TOLL EXCHANGE
TO HENDON EXCHANGE
1
0
2nd NUMERICAL SELECTORS
NUMBERING SCHEME
EDGWARE :- 0000 - 0999
1000 - 1299
FINAL SELECTORS (P.B.X 2/10)
FINAL SELECTORS (ORDINARY)

EDGWARE AUTOMATIC EXCHANGE ROUTINGS.

FIG. 2.

(5) *Junction Calls.* Assume Brixton 2345 is required, the D.S.R. junction and the Incoming 1st Code Switch at Maida Vale is seized in the usual way. When B is dialled the D.S.R. steps up to level 2, junction discrimination takes place, and the D.S.R. remains on level 2 until the completion of the call, but the wipers are disconnected so that no interference on this level takes place. The call is then routed *via* the plant at Maida Vale as in other Director Exchanges.

(6) *Level O.* This traffic is routed off 2nd Code Selector switch levels at Maida Vale direct to the A positions in the Auto-Manual Board in Maida Vale Auto Exchange. There the route procedure is as stated for a junction call.

(7) *Test Desk.* In this case the engineering officer dials XMA or XMD, the call is routed *via* Maida Vale as for a junction call. Local discrimination is not given for Test Desk calls, as several of the exchange names in the London area begin with W (9). It therefore becomes necessary to route the Test Desk traffic *via* the main exchange, two junctions being used, *i.e.*, one to Maida Vale and one back to Edgware 1st Numerical Selector Switches from level 36 of 2nd Code Selector switches at Maida Vale.

Barred Trunk Group Subscribers.

(1) *Local Calls.* Owing to the fact that O level calls are routed direct from the O level of the D.S.R., for reasons stated previously, it is necessary to provide a separate group of 1st Numerical Selectors for local calls. In this case local discrimination takes place when G has been dialled.

(2) *O Level Calls.* O is dialled by the calling subscribers, and immediately a free outlet is obtained the junction to the Incoming 1st Code Switch at Maida Vale is released, and the caller

connected direct to the A position at Maida Vale. Local discrimination takes place in this class of call.

Barred trunk subscribers requiring calls other than local and junction calls, (unit fee) should dial O, but in case the caller dials TOL or TEL or TRU, a separate group of circuits are provided at Maida Vale for "trapping purposes." See notes on Maida Vale.

(3) *Excess Fee Calls.* (Main and Barred Trunk Group Subscribers). Several exchanges in the London Automatic Area are excess fee calls to the Satellite exchanges. Therefore it is necessary to adopt some means of recording all excess fee calls originating from these exchanges. To do this, means are provided at Maida Vale for routing all excess fee calls to the Auto-Manual board, where the calls are completed by the A operators. The actual routing is given in the Maida Vale notes.

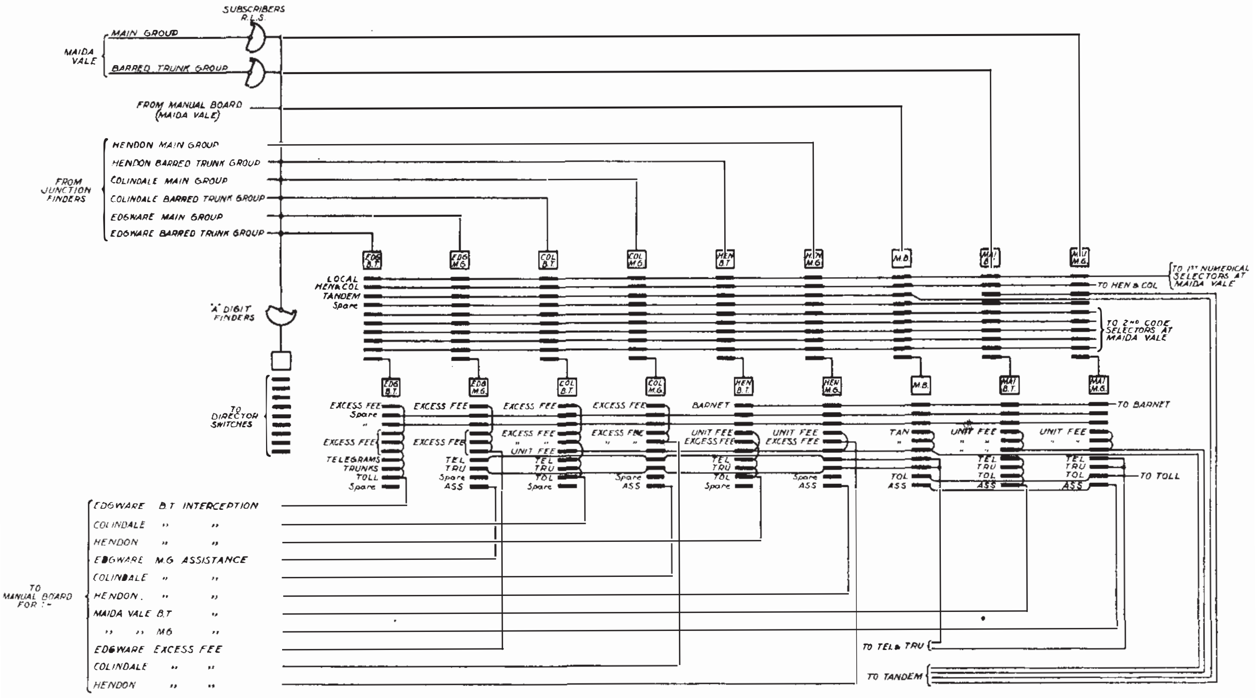


FIG. 3.—MAIDA VALE AUTOMATIC EXCHANGE ROUTINGS. THE SQUARES INDICATE 1ST AND 2ND CODE SELECTORS.

(4) *Incoming Calls.* A group of 1st Numerical Selector switches are provided at each Satellite exchange, to which the A operators on the Automatic Manual Board at Maida Vale have access. Only four numerical figures have to be dialled in this case. Groups of 1st Numerical Selector Switches are also provided at each Satellite exchange for calls originating in manual and automatic exchanges. In some cases, the traffic from automatic and manual exchanges is routed *via* Tandem, and in others those from the automatic exchanges are routed direct to the 1st Numericals at the satellites; and in the case of the manual exchanges these are routed *via* the Key Sender B positions at Maida Vale or *via* Tandem Key Sender B positions.

MAIDA VALE AUTOMATIC EXCHANGE.

The routings from levels 2, 3, 4, 5, and 6 of 1st Code Selector Switches at Maida Vale Automatic exchange have not been shown, as these routings follow the usual course as for a straight Director exchange. It will be seen that level 1 of all 1st code Selector Switches has been set apart to cater for the "trapping" or excess fee calls, also for calls to Assistance, Trunks, Toll and Telegrams for the Main and each Satellite exchange to the Auto Manual board. The following is a list of the various routings that had to be provided for *via* level 1 :—

(1) Calls Excess Fee from Edgware and not to Hendon or Colindale.

(2) Calls Excess Fee from Edgware, Hendon and Colindale.

(3) Calls Excess Fee from Edgware and Colindale, but not from Hendon.

(4) Assistance Calls for Edgware main group of subscribers.

(5) Assistance Calls for Hendon main group of subscribers.

(6) Assistance Calls for Colindale main group of subscribers.

(7) Assistance Calls for Maida Vale main and Barred Trunk group of subscribers.

(8) Interception circuits for Edgware barred trunk group of subscribers.

(9) Interception circuits for Colindale barred trunk group of subscribers.

(10) Interception circuits for Hendon barred trunk group of subscribers.

(11) Calls to Telegrams, Trunks for each of the Satellite and Main Exchanges.

Attention is drawn to the fact that the Incoming 1st Code Selector Switches provided at Maida Vale for the Satellite exchanges are somewhat different from those of the ordinary type fitted in Director exchanges, as it is necessary for these switches to send back to the Satellite exchange reversed battery conditions for metering purposes, a condition which is not required in a straight Director exchange 1st Code Switch. These Incoming 1st Code Selector Switches have been developed by the British Post Office engineers and are now accepted as standard.

It will perhaps be as well, at this stage, if the routing from each level of the 1st and 2nd Code Selector Switches was explained in Level order. The levels set apart for the "trapping" of excess fee calls are as follows:—

Calls Excess Fee to Edgware and not to Hendon and Colindale, Level 15.

Calls Excess Fee to Edgware, Hendon and Colindale, Level 16.

Calls Excess Fee to Edgware and Colindale only, Level 17.

As there are no excess fee calls from Maida Vale subscribers, no special arrangements have to be made in this case; therefore levels 15, 16 and 17 route unit fee call *via* Tandem exchange.

Levels 1, 2, 3, 4, 5 and 6. 1st Code to 2nd Code. Selector Switches.

Level 7. Spare.

Level 8. This level is set apart for all unit fee calls routed *via* Tandem from the Satellite exchanges, and the Auto Manual board. The junctions to Tandem are of high-grade type, and are provided so as to avoid transmission losses. Level 8 also covers the traffic routed *via* Tandem for Maida Vale subscribers; high-grade circuits are not required in this case.

Level 9. For all calls to Hendon subscribers from Maida Vale, and to Colindale subscribers from Maida Vale and Satellite exchanges.

Level 0. Calls from all the area subscribers are routed *via* this level to the Maida Vale subscribers.

Level 11. (Assistance).

It will be seen that separate groups of circuits have been provided for Assistance calls for each Satellite Main group of subscribers, and also separate groups of circuits for the Main Exchange Main group, and Barred Trunk group of subscribers; this being necessary so that the operators at the Auto Manual board can identify the origination of the call.

No circuits are provided for the Satellite Barred Trunk group of subscribers, as it will be seen that Assistance calls in this case are routed direct from the O level of the D.S.R. at the Satellite exchange. (See notes on Edgware).

Levels 12, 13 and 14. In the case of the Barred Trunk group of subscribers from the Satellite exchanges, these levels are teed together and connected to the Auto Manual board, this arrangement being desirable so that should a Coin Box subscriber dial TOL, TRU, or TEL the call will be routed to the Auto Manual board. Of course, as previously stated, a Coin Box subscriber should dial O for all calls other than unit fee, and as Call offices are often used by regular subscribers who are in the habit of dialling TOL, etc., from their own telephone, it was decided to guard against this happening by the provision of a special group of circuits shown as BT interception.

Should a call be received on these circuits at the Auto Manual board, the subscriber will be unable to speak to the operator unless the subscriber presses Button A on the Coin Box, in which case the operator will then complete the call, but should the operator be unable to hear the calling subscriber, the operator will inform the subscriber to dial O for the call and press

Button B (which returns the coins to the caller).

Level 15. This level is set apart for the purpose of routing excess fee calls from Edgware Main group subscribers to the Auto Manual board, and it will be seen that a separate group of circuits have been provided for this purpose. It will also be noticed that level 15, to which Hendon and Colindale Main and Barred Trunk subscribers have access, is available for unit fee calls and is not therefore "trapped" on the Auto Manual board. For excess fee calls from the Edgware Barred Trunk subscribers, it will be seen that levels 15, 16, 17 and 10 are teed to levels 12, 13 and 14 and routed to the Manual board. The subscriber should, in these cases, dial O, as previously stated; therefore this class of call will not be considered when the routing of excess fee calls from the Satellite Main groups is being explained. For the Maida Vale Main and Barred Trunk subscribers, level 15 is a unit fee call level, and these calls are routed *via* Tandem.

The procedure followed when an Edgware subscriber dials for an excess fee call. (The procedure laid down will be the same as that for the other Satellite exchanges). Assume a call is being made to Albert Dock 2345, the direct translation will be 1542-2345, 1542 being the translation to route the call *via* Tandem. On the 15 being sent out by the Director Switch, a First Code Switch of the Edgware group steps up to level 1 of the 1st Code, then the 2nd Code Switch steps up to level 5 of the 2nd Code, and an outlet to the Auto Manual board is obtained, the remaining impulses, *i.e.*, 42-2345, being received on the calling lamp on the Auto Manual board. As the calling lamp will flicker under these conditions, the operator delays answering the call until the remaining impulses have been received.

The operator in answering the call ascertains from the subscriber his requirements (in this case ALB 2345); the operator then originates the call *via* the Manual Board 1st Code Selector Switches. The A digit and Director switch again accepts ALB 2345, when dialled by the operator, which is again translated into 1542-2345, but on 15 beng sent out it will be seen that the call is routed to Tandem, and not to the Auto Manual board *via* level 5 of the Manual board 2nd Code Selector Switches, 42 being accepted by the switches at Tandem (level 42 being the level in Tandem for all calls to Albert Dock), the 2345 appearing on the C.C.I. display at Albert Dock Manual Exchange in the usual manner.

Level 15 in the case of the Colindale Main and Barred Trunk group, and also the Hendon Main and Barred Trunk Switches, is provided for calls that are unit fee for these exchanges. The calls originated by subscribers in these groups are routed similarly to calls originated from the Auto Manual board, as quoted in the foregoing paragraph.

Level 16. This level provides for the routing of calls to the Auto Manual board that are excess fee to all Satellite exchanges, and it will be seen that the separate groups of excess fee circuits are required for each exchange, it being necessary to provide these separate groups for identification purposes from a traffic point of view.

The treatment of calls is as stated in the case of excess fee calls for Level 15. Beckenham exchange is an excess fee call from all the Satellite exchanges; therefore a call to Beckenham 2345 will be translated to 1603-2345 and level 16 will route the call to the Auto Manual board in the case of the originating subscribers, and *via* Tandem to Beckenham when the call is originated from the Auto Manual board. Level 16 of the Barred Trunk group is teed to the Barred Trunk Interception circuits for reasons previously stated.

Level 17. This level provides for calls to exchanges that are excess fee to Edgware and Colindale, but not to Hendon. The call is dealt with in a similar manner as for calls on levels 15 and 16.

The calls from Hendon which are unit fee calls are routed *via* Tandem, as will be seen from the routing diagram.

Grangewood is an exchange that is an excess fee call from Edgware and Colindale and a unit fee from Hendon; therefore a call originated by a Hendon subscriber and from the Auto Manual board will be routed *via* Tandem, where Level 58 is set apart for calls to Grangewood, the full translation of Grangewood 2345 being 1758-2345.

Levels 18 and 19 are spare.

Level 10. In this case a direct group of junctions is provided from Maida Vale Auto exchange to Barnet, and Barnet being an excess fee call to Edgware and Colindale subscribers but not to Hendon, it becomes necessary to set apart a separate level for routing calls to this exchange. The translation in the Director Switch for a call to Barnet 2345 will be 10-2345 and the treatment of the call to this exchange will be as for other excess fee exchanges.

It will be seen that all excess fee calls other than those to Barnet are routed *via* Tandem, this being economical from an engineering point of view.

It is not proposed to explain the routing *via* levels 2, 3, 4, 5, and 6 of the 1st Code Selector Switches, as these follow the usual practice as for other Director exchanges in the London Automatic area.

Incoming Calls (Automatic).—In the case of calls originating at other automatic exchanges in the London area, the calls are routed, either direct from the automatic exchange or *via* Tandem exchange. In the case of direct routing the incoming junctions terminate on separate groups of 1st Numerical Selector Switches, either in the Main or Satellite exchanges, but if the calls are routed *via* Tandem a group of 1st Numerical Selector Switches at the Main or Satellite exchanges are utilised.

Incoming Calls (Manual).—Calls from these exchanges are routed *via* the Key Sender B positions at Maida Vale. The 1st Numerical Selector Switches for groups of junctions from each Manual exchange provided with direct groups of junctions are situated in the respective exchanges.

A typical example of the routing of an incoming Manual call is as follows:—

The distant A operator demands a call over the order wire, say, to the operator on the Edgware Key Sender B position in the Maida Vale exchange. The operator on this position keys up the four numerical digits, and the selector switches at Edgware respond to the impulses sent out by the sender. (A common group of senders is provided at Maida Vale for all Key Sender B positions).

If a call is received for Maida Vale, or Hendon and Colindale the same procedure is adopted, but the respective Key Sender B positions are used and the Selector Switches, at the respective exchanges, are brought into operation.

All incoming calls from manual exchanges which do not warrant direct groups of circuits are routed *via* the Key Sender B positions at Tandem, and are then completed *via* the incoming Tandem group of 1st Numerical Selector Switches at the respective exchanges.

The operators at Tandem in the disposal of these calls, key up the exchange code and the numerical digits. (7 digits).

As it will not be possible to give full details of all the service circuits that are connected to the A position, two of the more important services provided, with remarks thereon, are as follows:—

Monitors and Service Calls.—The usual practice is followed as for other Director exchanges, the code and numbers to be dialled are:—

	Maida Vale	Hendon and Colindale.	Edgware.
Monitor	Mai 0001	Col. 0001 or Hen. 0001	Edg 0001
Service	Mai 0101	Col. 0101 or Hen. 0101	Edg 0101

The calls are routed from the Final Selector Switches at the respective exchanges to the A positions in Maida Vale exchange.

It is not intended that the above monitor circuits should be obtained from subscribers' telephones in the London Auto Area, as registration of the meter would take place when the operator answered. The subscriber is instructed to dial O for all Assistance (Monitor) or Service calls.

The circuits are provided to enable other Auto Manual board and Manual exchange operators to obtain Monitor or Service calls at these exchanges. (Maida Vale, Edgware, Hendon and Colindale).

Centralised Observation. — Observations of subscribers' service are being carried out on a centralised basis in the London Automatic Area. The centralised observation positions are situated in a room in the Metropolitan-National Automatic Exchange building.

To enable subscribers' circuits to be connected for observation, tapping equipments are provided at each automatic exchange. The equipment provided at each exchange in this area is as follows:—

Maida Vale—14 Tapping equipments + 1 Junction.
Hendon —10 ,, ,, } + 1 ,,
Colindale — 6 ,, ,, }
Edgware —12 ,, ,, + 1 ,,

It should be noted that observation of the subscribers' service at each exchange is on an auto-selective basis; therefore the observation officer has no control over the choice of any particular subscriber's circuit in a group connected to the tapping equipments for observation purposes.

I am indebted to Messrs. Automatic Telephone Manufacturing Co., Ltd., of Liverpool, for the photograph of the Discriminating Selector Repeater.

FULHAM EXCHANGE, LONDON.

Contributed by

STANDARD TELEPHONES & CABLES LTD., LONDON.

BY the opening of Fulham Automatic Telephone Exchange which was successfully brought into service at 2 p.m. on Saturday, 27th July, 1929, another link was added to the rapidly growing network of automatic exchanges in the London Telephone Area.

The exchange has capacity for 9,700 lines, the present equipment being for 7,500 lines; of this number 2,400 were actually cut-over on the date mentioned. The quantity of each type of apparatus installed can be readily ascertained from the diagram (Fig. 1) showing the switching scheme for the exchange.

The exchange is accommodated in a new four-storey building, near the junction of Lillie Road and North End Road, Fulham. The automatic equipment is distributed over the 1st and 2nd floors of this building, whilst the manual switch-

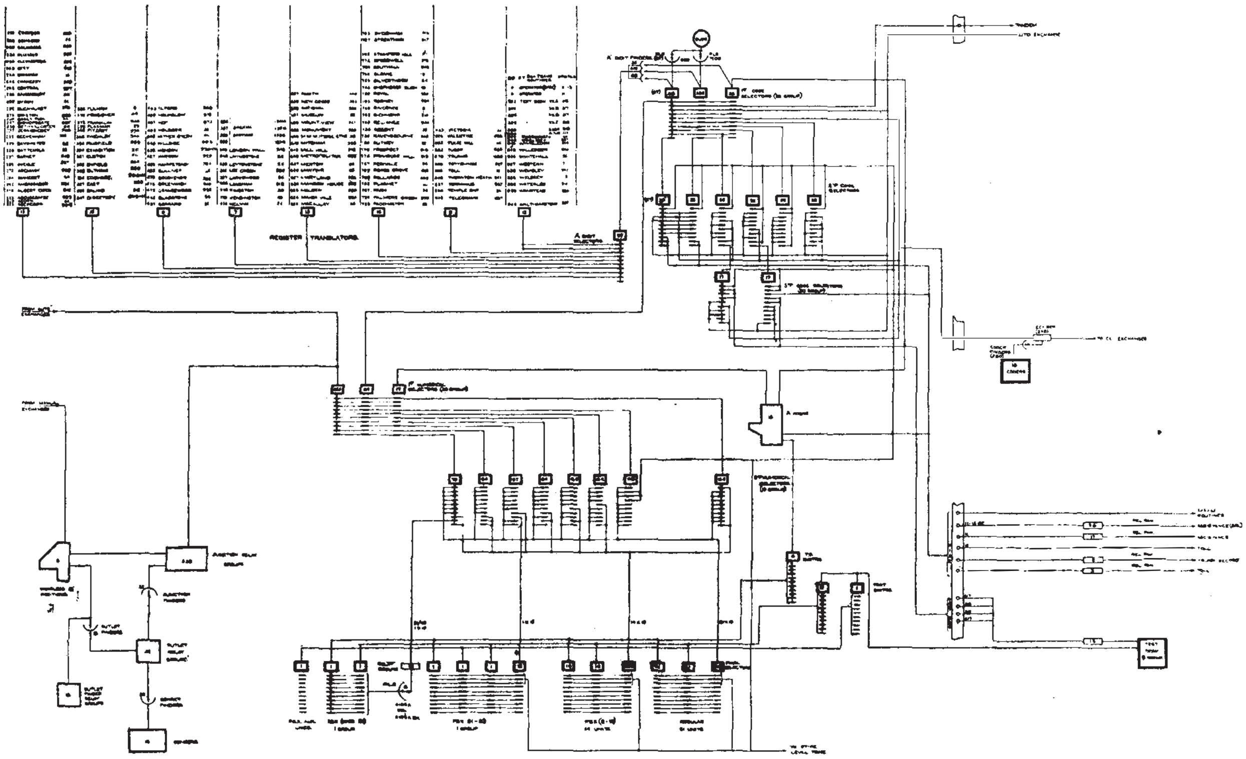


FIG. 1.—SWITCHING SCHEME.

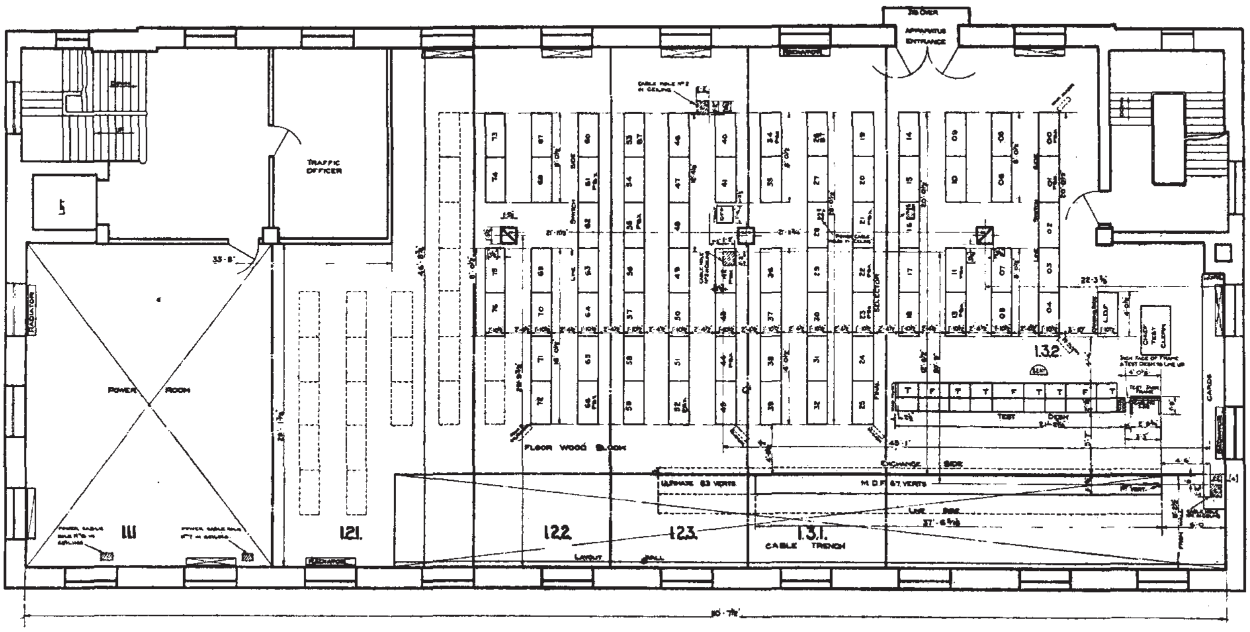


Fig. **2**.—Automatic Switchroom, First Floor.

boards are located on the 3rd floor. The lay-out of the equipment on each of these floors is shown in Figs. **2**, **3** and **4**, and it will be seen that the accessibility of all apparatus has been carefully studied, to facilitate maintenance work. The equipment was manufactured and installed by Standard Telephones & Cables, Ltd., and constitutes the first exchange in the London area supplied by this contractor in which the geographical supervisory scheme, designed by the Department's engineers, has been adopted. This scheme enables the maintenance officers to supervise the whole of the equipment from any position in either of the automatic switchrooms. For the exploitation of the scheme the equipment on each floor has been divided into two sections, and six sub-sections. In a prominent position on each apparatus floor, is situated an alarm

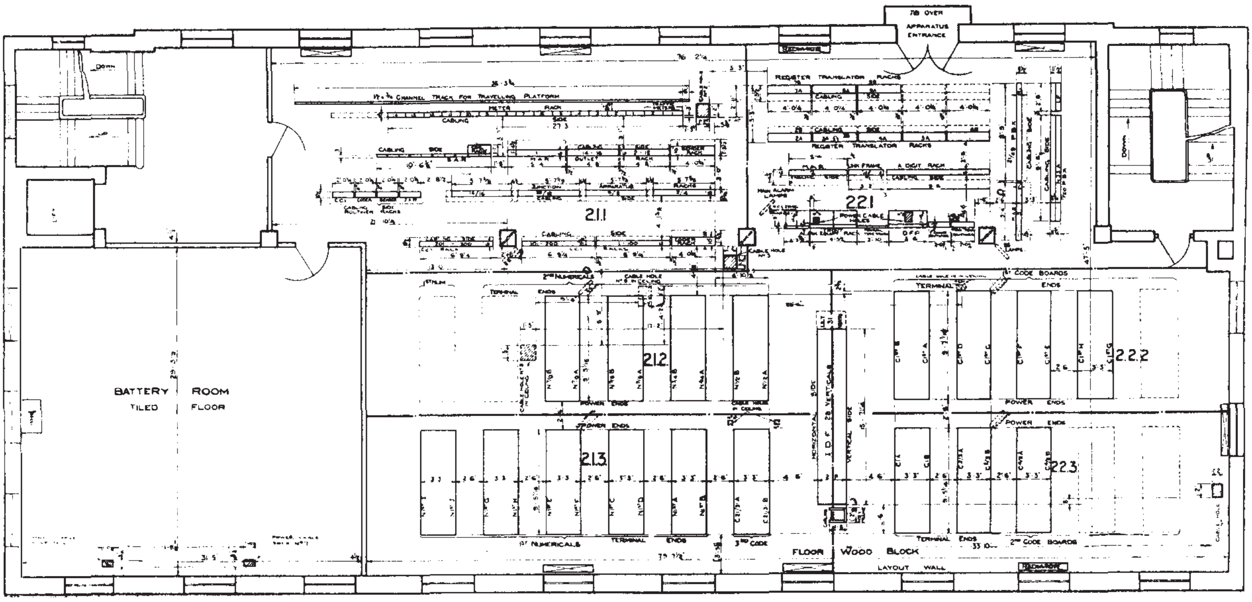


Fig. **3**.—Automatic Switchroom, Second Floor.

centre consisting of illuminated indicator boxes, which, in the event of a fault occurring show on which floor and in which section the faulty apparatus is located. The rapid location of the fault is further facilitated by the provision of section and sub-section supervisory lamps.

First Floor.—On the 1st floor are found the subscribers' line and final selector units, the link distributing frame, the M.D.F., and test desks, whilst at the other end of the same floor, the charging machines and the power board are located.

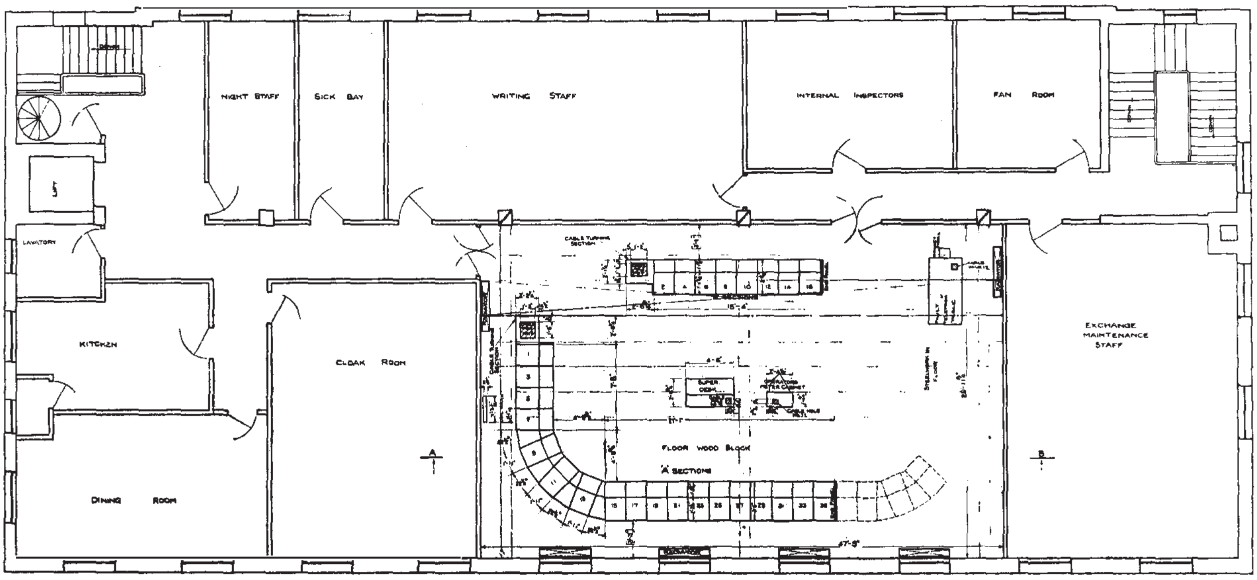


FIG. 4.—MANUAL OPERATING ROOM.

The equipment is so arranged with relation to the windows that full advantage is taken of the daylight. In Fig. **5**, in which a view of the subscribers' line and final units is shown, it will be observed that busbars are used for power distribution. These are of special interest since they are of aluminium, and Fulham is the first telephone exchange to be opened in this country where aluminium busbars have been employed for power distribution.

Second Floor.—This floor carries the remainder of the automatic equipment and exchange apparatus, the lay-out of which has been very well arranged. The Message Register Rack is placed facing the window so that under normal daylight conditions no artificial light is required. The distribution fuse panel and alarm equipment racks are situated in the centre of the room with the 1st code selector boards in front, and the " A " digit and register translator racks immediately to the rear, whilst their respective routiners are in line with them.

The minor switches on the register translators are fitted with the cup spring in place of the spiral spring originally adopted.

A new design of " A " digit rack has been introduced, having all the apparatus on one side only, and in line with each level of switches is situated the grading and routiner access equipment associated with it. This feature also appears on the P.B.X. final selector rack. The C.C.I., coder, sender, and junction apparatus routiners, shown in Fig. **7**, are adjacent to the apparatus with which they are associated.

A view is included of the 1st code selector racks in Fig. **8**: the two sides of each of the 1st code selector racks can now be dissociated for N.U. tone and busy flash, a new U-link being embodied in the type of distribution point now employed.

The local alarm lamps on the sender racks consist of P.O. No. 2 lamps, mounted on phenol fibre fuse panels, at about shoulder height, instead of the tubular pattern hitherto employed and mounted at the top of the racks.

Three miscellaneous apparatus racks are accommodated on the 2nd floor, of which one is for the " O " level and linesmen's circuits, one for T. and T.O. distributors, and T. and T.O.

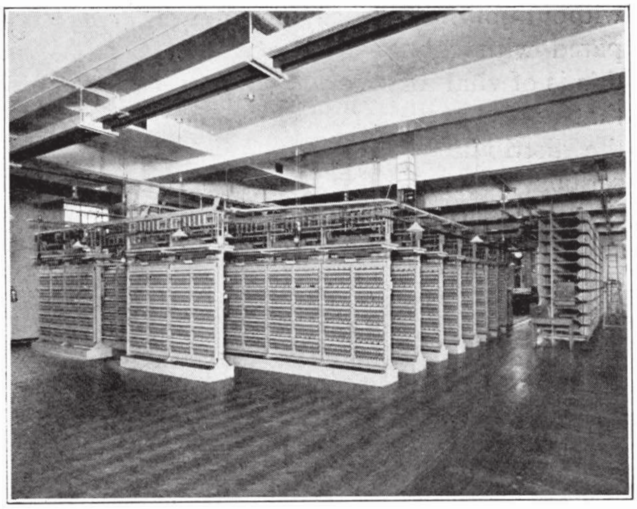


FIG. 5.—SUBSCRIBERS' LINE AND FINAL SELECTOR UNITS.

and P.B.X. final selectors, and the third is for changed number circuits. The object of the last-named circuit is to route a call for a subscriber whose number has been changed, directly and automatically to a changed number jack on the manual board, where an operator informs the caller of the new number and completes the call.

One noticeable feature of the automatic rooms is the quieter operation of the equipment, steps having been taken to reduce noise wherever possible; as an example the new type of time pulse count relays may be mentioned. In this case the interminable . . . " clack " . . . . " clack " . . . of the relay-operated pivoted rachet, has been eliminated by utilizing a switch of the RLS type which takes a step every 1½ seconds until the delayed alarm period contact has been reached.

Third Floor.—The manual operating room is a light, well ventilated apartment at the top of the building. A view of this room showing the

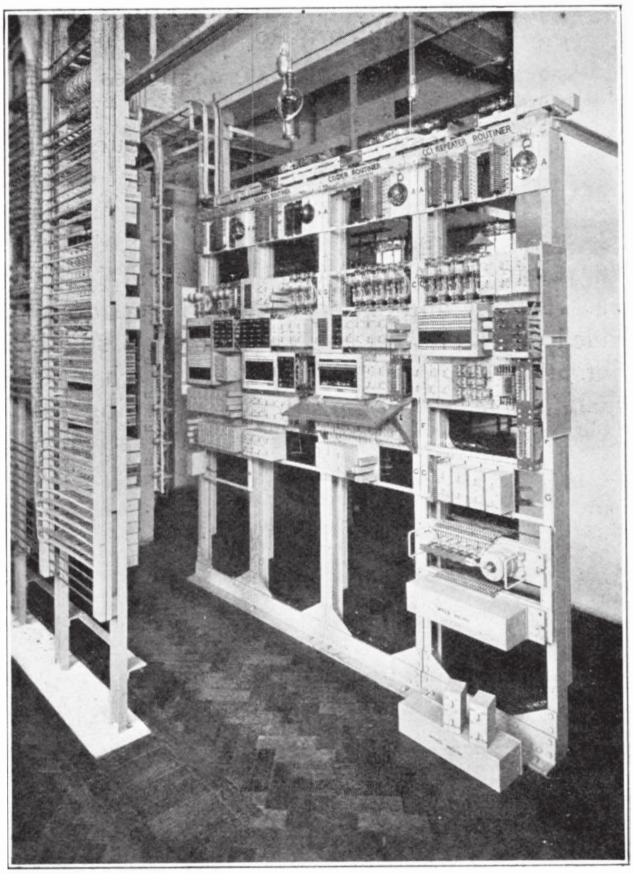


FIG. 7.—ROUTINERS.

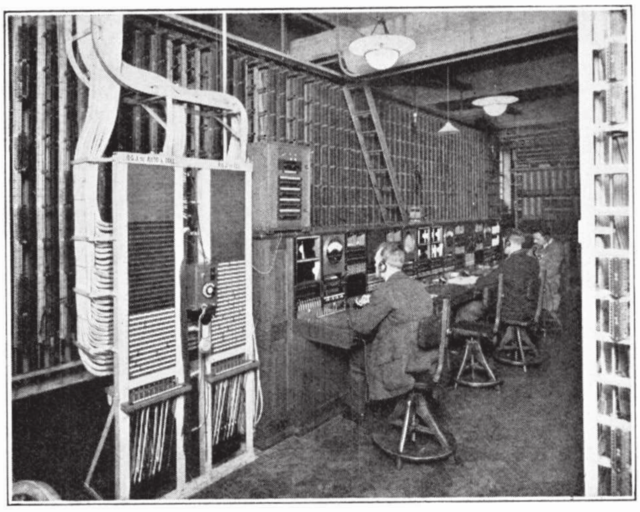


FIG. 6.—TEST DESK AND M.D.F.

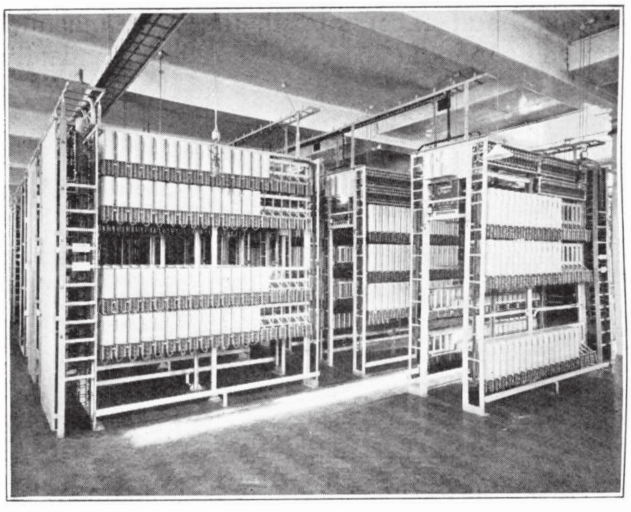


FIG. 8.—SELECTOR BOARDS.

manual "A" sections, and the cordless "B" sections, is shown in Fig. **9**.

Power Plant. — Duplicate batteries of 25 Chloride "Planté" type cells are provided, having a capacity of 3,900 ampere hours at the 9 hour rate. This charging equipment consists of two 35 KW motor generator sets manufactured by Messrs. Crompton Parkinson, designed to operate from the 200 volt 2 phase supply. The usual supply and battery-driven ringers are provided together with the Department's standard automatic change-over equipment which ensures that, in the event of the supply-driven ringer failing, the stand-by battery-driven set is started up and the ringing and tone circuits are automatically transferred. Duplicate rotary converter-alternator sets are provided to generate 3 phase alternating current at 40 and 20 cycles to drive the small A.C. motors associated with the coder, director and sender impulsing equipment. Each rotary converter is provided with a vibrating centrifugal governor arranged to vary the resistance in the converter field in such a manner as to maintain the speed of the machine within limits of 1½% on either side of the normal for all conditions of load, supply voltage and machine temperature. Since the speed of the individual motors operating the separate impulsing interruptors depends on the frequency generated by the main driving machines, the rate of impulsing is maintained constant within remarkably close limits. Provision is also made so that in the event of the speed of the main driving machine exceeding predetermined limits, or in the event of a failure in any of the supply leads, the faulty machine is at once stopped, the spare machine started up, and the load transferred automatically with a minimum of disturbance to the exchange.

Reference has already been made to the use of the aluminium busbars at this exchange. With regard to the power plant also, aluminium is used in place of copper for power distribution, and the installation, if considered as an experiment, has proved entirely successful, a considerable reduction in weight having been achieved without any electrical disadvantages. All joints are clamped and though the amount of overlap is only about 2½ inches, the resistance of one foot of conductor including joint is invariably less than one foot of the same conductor without joint. The saving in weight as compared with copper is approximately 50%, and this is of vital importance when it is remembered that in the very large exchanges the weight of the distributing conductors is becoming a very serious problem. For the conductors between the generator and the power board, aluminium rod has been substituted for the usual V.I.R. lead-covered cable. This rod is carried in floor chases supported on porcelain insulators. This again is a novel feature which can be adopted with considerable advantage in the case of large generators where, hitherto, it has been the practice to employ a number of heavy cables which are difficult to place in position and which cannot be bent over a short radius. It might be mentioned here that the Department's engineers were among the first to make use of aluminium for power distribution. Through the courtesy of the Engineer-in-Chief, our engineers were permitted to inspect the aluminium busbars in the substations at Mount Pleasant and St. Martin's le Grand, and the adoption of aluminium at Fulham Exchange is largely the result of impressions obtained during these visits. The authors are indebted to the Engineer-in-Chief of the Post Office for permission to publish this article, and to the courtesy of the Board of Editors of this Journal for its publication.

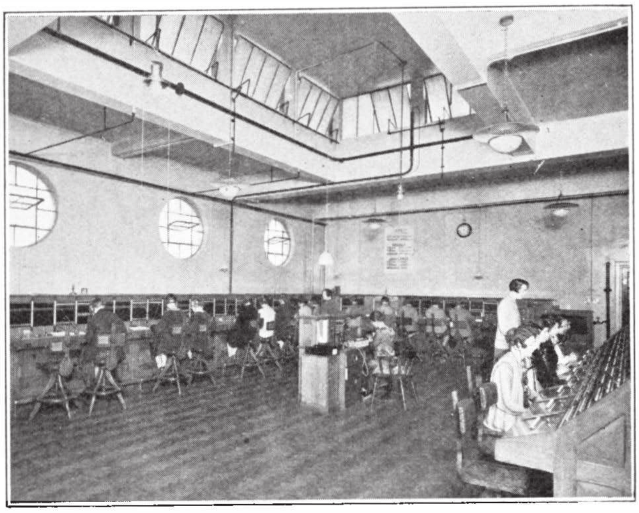


FIG. **9**.—MANUAL OPERATING ROOM.

PORTABLE EMERGENCY BATTERY CHARGING SETS.

H. C. JONES, B.Sc. (Hons.).

PROBABLY the most important consideration underlying the design of telephone exchange power plant is reliability and the necessity for obviating as far as possible any chance of interruption of the power supply. Despite the fact that all large exchanges are provided with duplicate batteries and charging machines and are often served by two separate power supplies, the failure of the charging arrangements has occurred sufficiently frequently to justify the provision of an additional means, in the form of portable charging sets, to safeguard the service. A number of small portable sets, several having outputs of up to 300 amps., have been available in various parts of the country for a number of years, and these, although not specially designed for the job, have given useful service. The development of large automatic exchanges and repeater stations has, however, necessitated the provision of much larger and reliable machines, and the first of these has recently been put into commission in the London District for use in case of emergency at any large installation in South-East England. It will be followed shortly by three other similar machines for serving installations in other parts of the country.

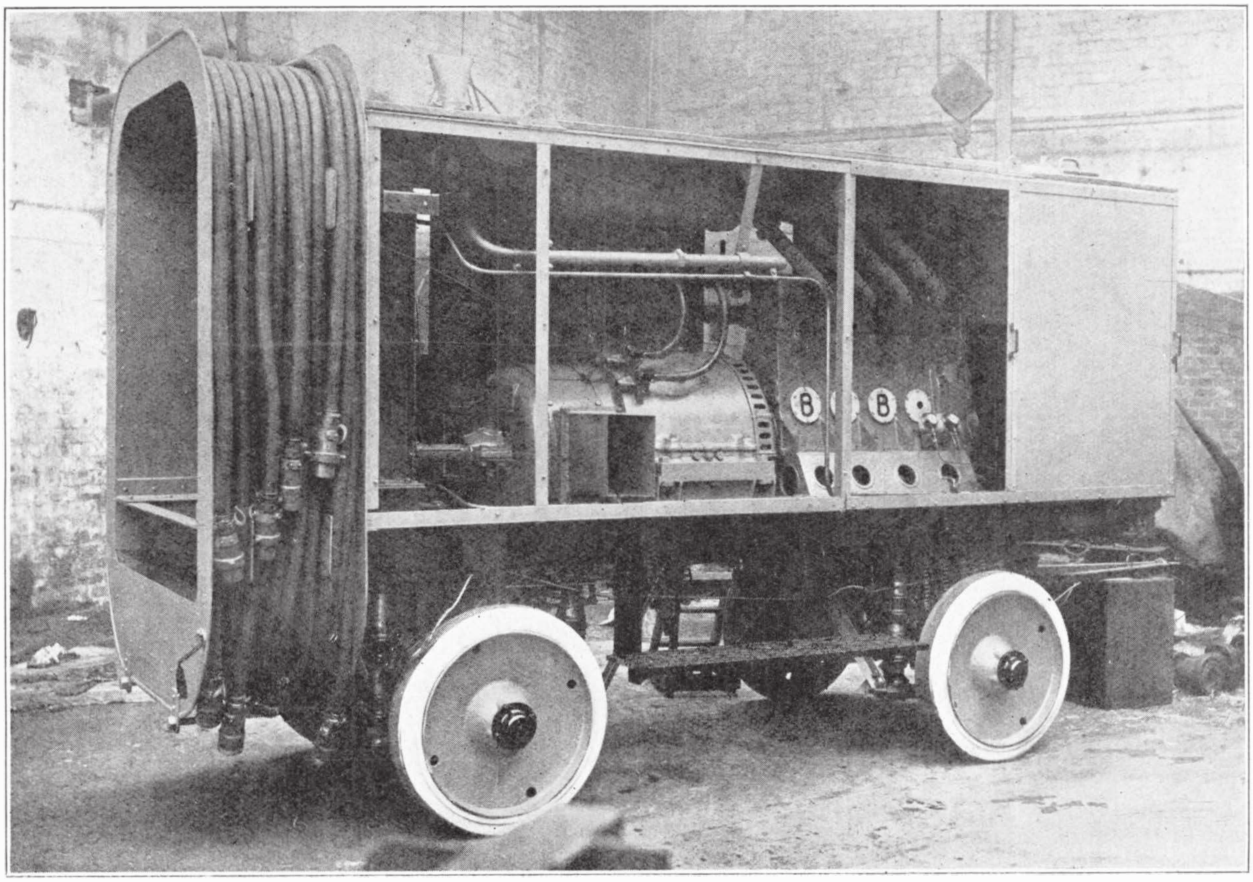


FIG. 1.—EMERGENCY BATTERY CHARGING SET.

The accompanying photographs are self-explanatory, and give an idea of the size and construction of the set, which was constructed by Messrs. W. Beardmore & Co., of Glasgow. The prime mover is a high speed, light weight, 4-

cylinder Diesel Engine, and is of the same type as those used on the new airship, the R 101, but is, of course, considerably smaller. It runs on crude oil, which is injected under pressure into the cylinders, and is fired automatically by the heat produced during compression stroke. The fuel consumption is approximately 0.45 lbs. per B.H.P., and the fuel tank holds about 50 gallons, which is approximately the quantity necessary to fully charge the largest batteries at present installed in Post Office premises. Crude oil has an obvious advantage over petrol from the point of view of safety, and is also at least 50 per cent. cheaper to use. The engine is rated at 100 B.H.P. when running at its full speed of 1,200 R.P.M., but the speed can be adjusted at will by regulating the loading of the governor. The engine is water-cooled, the water being pumped through the circulating system and cooled by a fan-cooled radiator.

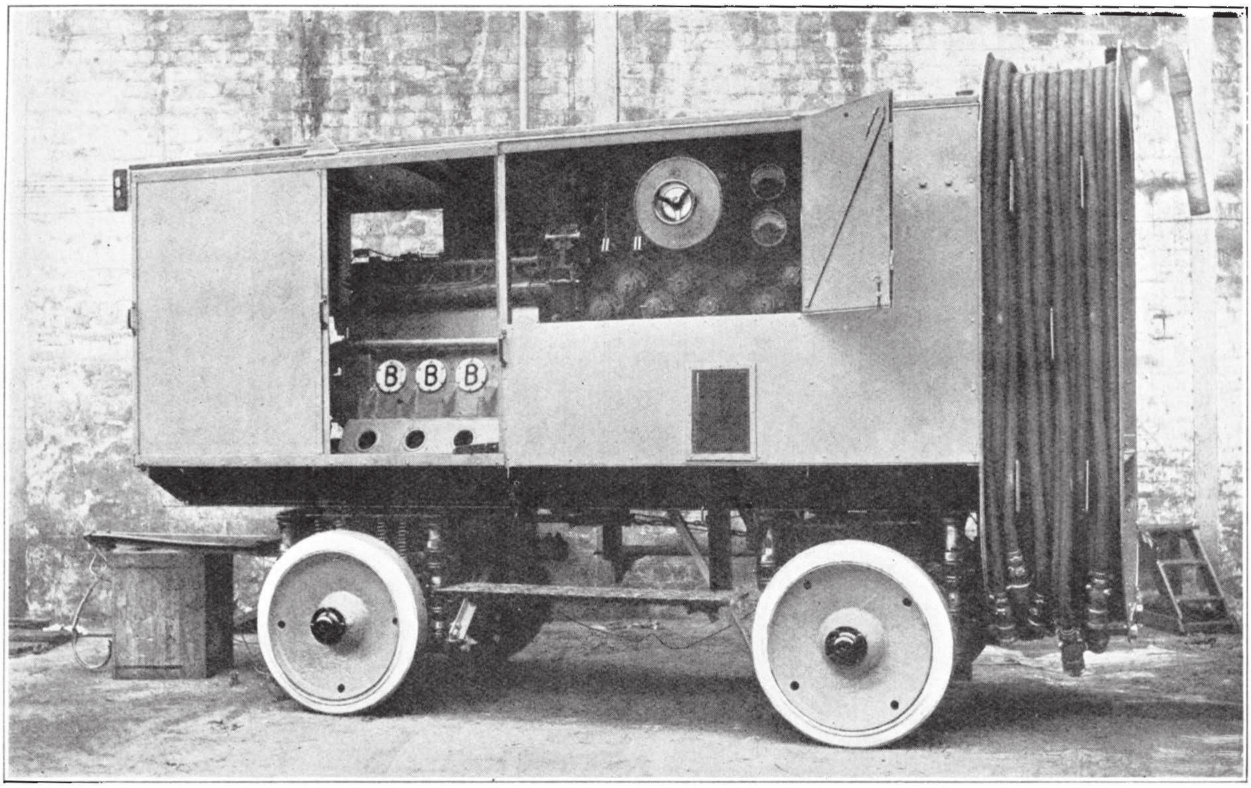


FIG. 2.—EMERGENCY BATTERY CHARGING SET, SHOWING SWITCHBOARD

The method of starting is very simple, yet effective. Prior to starting, all the exhaust valves are opened by the hand operation of a special cam shaft, and compression in the cylinders during the starting operation is thus prevented. A small petrol engine of the motor cycle type with twin cylinders is started by hand and drives through a Hookes joint, a shaft carrying a grooved friction wheel. By virtue of the flexibility allowed by the Hookes joint, the friction wheel can be engaged with the flywheel on the engine crank shaft, which is thus caused to rotate. The engine having been brought up to speed, the exhaust valves are released and the inertia of the moving parts is then sufficient to overcome the compression and start the engine. The starting engine is then shut down.

The generator, which was manufactured by the British Thomson Houston Co., is a pipe-ventilated shunt-wound machine, capable of supplying 1,000 amps. at up to 67 volts or an equivalent amount of power up to 100 volts. Its output is regulated by a combination of variation of engine speed and field regulation. It is controlled by a switchboard, which can be seen in the photographs, upon which the instruments are flexibly mounted, so as to nullify the effects of vibration.

Eight 60 ft. lengths of 646/.029″ (0.4 sq. in.) single, flexible, cab tyre, asbestos-sheathed cable with 500 amp. plugs and sockets are provided for distributing the power from the switchboard to the exchange batteries. The cables, which in all weigh about $\frac{3}{4}$ ton, are accommodated, when not in use, on a rectangular drum on the end of the vehicle.

The chassis is specially sprung to keep the engine in a vertical position irrespective of the lie of the ground and, in view of the weight of the vehicle, about $8\frac{1}{2}$ tons, special attention has been paid to braking. In addition to the ordinary braking, an arrangement is fitted to automatically apply the brakes should the vehicle move backwards and, in order to facilitate manœuvring, a braking device is also fitted on the turntable.

Several tests which have already been made under actual working conditions have demonstrated the suitability of the set for emergency use. In spite of its weight, it holds the road well, and can rapidly be hauled from place to place. Having arrived on site, the cables, under average conditions, can be led into the building and coupled up and charging commenced within half-an-hour. The only defect in the set was the fact that at first it created a considerable noise when operating on full load. A number of modifications, which included the provision of additional stays for the sheet iron canopy, modifications to the silencer, lining the canopy with sound-absorbing material and the provision of a partition to prevent noise from passing outside from the engine *via* the radiator, have very considerably reduced this trouble, however, and the set can now be considered to be satisfactory in all respects.

MANCHESTER AUTOMATIC AREA: NEW UNDERGROUND LINES.

IN connection with the conversion to automatic working of the Manchester Telephone Area, some very considerable underground works have been undertaken during the past four years in the Cities of Manchester and Salford, and it is thought that a brief account of these works may be of general interest.

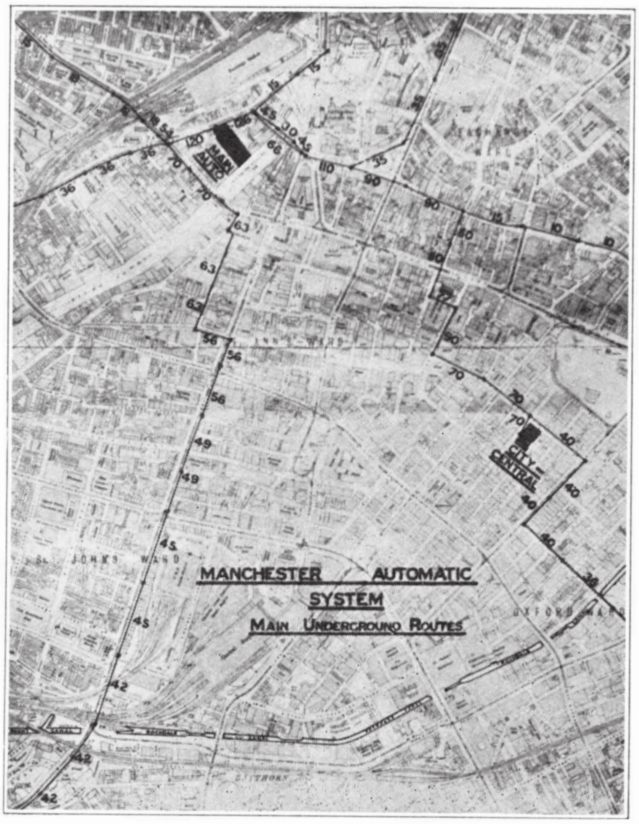


Fig. 1.—Outline of new Duct-work.

A very large Exchange building, designed to accommodate three 10,000 line automatic subscribers' units, the manual board for the Manchester Automatic area, and the new Toll Exchange, has been erected in Chapel Street, Salford, and the new duct line network radiates from this point.

Fig. 1 is an outline plan of the main sections of new duct-work. It will be observed that very large nests of ducts have been provided in certain thoroughfares, the heaviest sections being those connecting the new Exchange building with the Head Post Office (Trunk Exchange, Repeater Room, etc.) and the existing City and Central Exchanges in York Street.

Fig. 2 illustrates the construction of the new Exchange manhole in Chapel Street. The in-

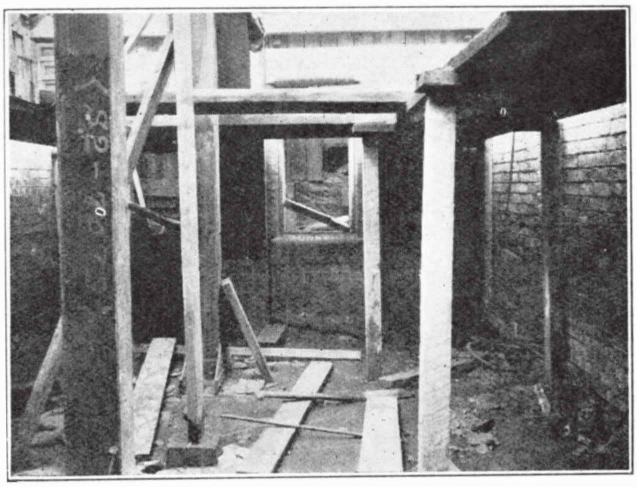


Fig. 2.—Construction of Exchange Manhole.

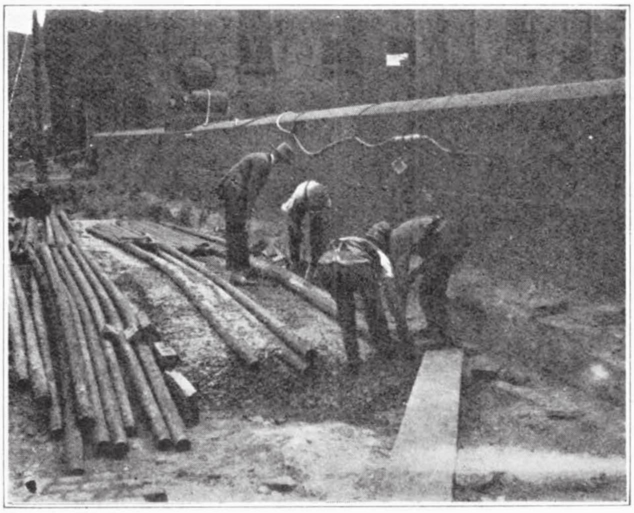


FIG. 3.—VICTORIA BRIDGE. LAYING STEEL PIPES.

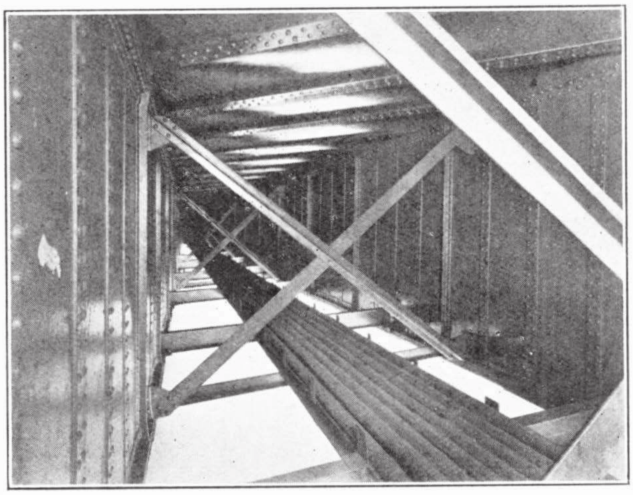


FIG. 4.—STEEL PIPES CROSSING PALATINE BRIDGE.

ternal dimensions of this manhole are—length 20′, width 14′, height 10′ 3″. The walls are of 21″ Accrington Brickwork, and the roof consists of an 8″ reinforced concrete slab resting on steel joists, of which the main member is a girder, 21′ long and of 14″ × 6″ section, stiffened by two uprights of 8″ × 6″ section. The floor is of reinforced concrete in two layers of 5″ and 12″ respectively, interposed between which is a 1″ layer of mastic asphalte. This asphalte layer is taken out to the back of the brickwork, up behind the walls, and in over the roof, so completely enclosing the manhole, except where it abuts on the Exchange building, in a watertight envelope. Three entrances are provided to facilitate access and cabling.

One of the most difficult sections of the work was that crossing the River Irwell by the Victoria Bridge. 110 ducts were scheduled for this section, but owing to lack of "cover" on the bridge it was found possible to lay only 96, these being taken across in two separate tracks, 66 on the South side and 30 on the North. At either end of this section octagonal ducts were laid, but on the bridge proper, double-spigot steel tubes were used (Fig. **3**), jointed by means of short W.I. collars. At the shallowest point, tubes specially bent had to be used. The tubes were jointed to the octagonal ducts at either end by bedding in cement mortar after the abutting ends had been wrapped with calico strips.

In consequence of the many obstructions the completed duct-line section, in which is included the bridge crossing, unavoidably contained highly complex curves in both vertical and horizontal planes, and anxiety was felt as to its practicability for cabling. Every stage of the

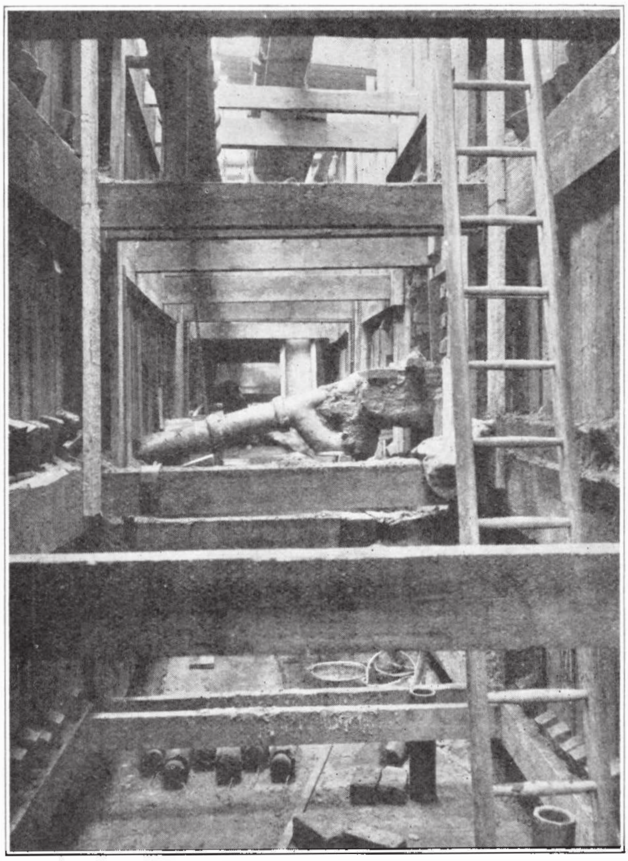


FIG. 5.—TRENCH FOR 126-WAY DUCT-LINE IN CHAPEL STREET, SALFORD.

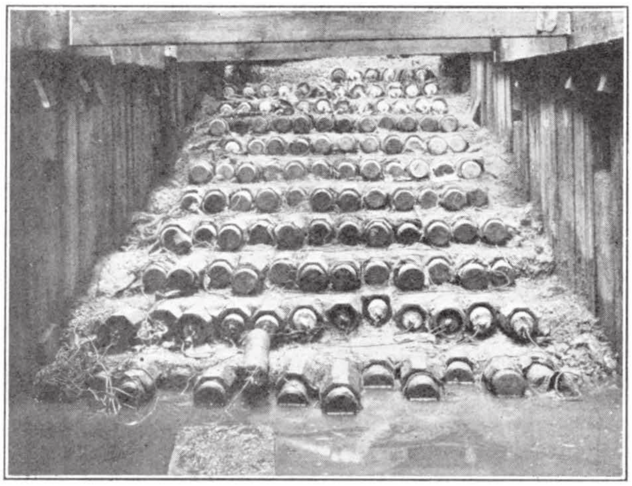


FIG. 6.—PARTLY CONSTRUCTED 126-WAY DUCT.

work, however, was closely watched and tested, and cables of the largest size have since been drawn in without difficulty.

The lay-out of the lines in this part of the area was considerably affected by unrecorded and unexpected obstructions in the form of disused vaults, passages, cellars and old foundation works generally. In one case a heading which was being driven under Deansgate for the accommodation of the 66-way line from Victoria Bridge Street ran into a series of vaults of great size and very solid construction. There were seven of these vaults, with walls four feet thick, lying in our track, and it was found necessary to build an extra manhole of considerable size in order to obtain a sufficient deflection of the track.

Fig. **4** shows a nest of 15 steel pipes accommodated on the steel under-structure of Palatine Bridge, another of the bridges crossing the River Irwell.

Figs. **5** and **6** show work in progress on the 126-way octagonal duct section in Chapel Street, Salford.

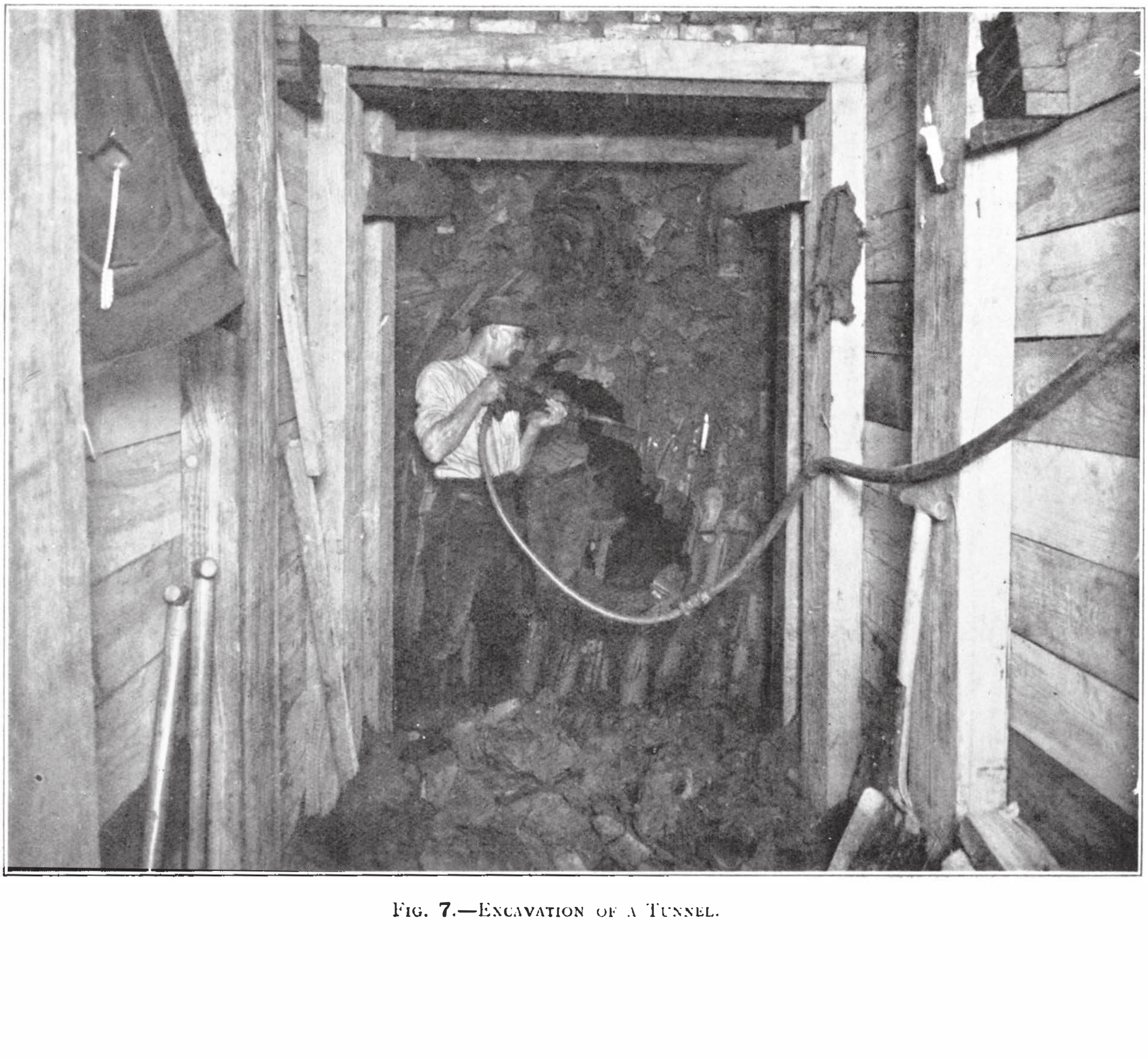


FIG. 7.—EXCAVATION OF A TUNNEL.

Owing to shallow obstructions and heavy street traffic, sections of duct-line aggregating to about 2,000 yards in length were constructed in tunnel. Figs. **7**—**10** illustrate the general nature of the operations involved. Fig. **7** shows the joining up at the centre point of two headings driven from opposite ends of a section. Fig. **8** shows a heading completed and the work of brick packing the spaces between the side trees in progress. Fig. **9** shows the " formers " for the concrete side walls of the chase intended to contain the octagonal ducts. It will be observed that the walls were constructed by a method differing somewhat from that described in T.I.XIV., inasmuch as, instead of being built up in shallow strips in step with the laying of the several tiers of ducts, they were built to their full height in one operation by the use of the " formers " seen in the illustration. This method was adopted in order to make the walls more nearly watertight by avoiding the numerous horizontal joints in the concrete entailed by the ordinary method.

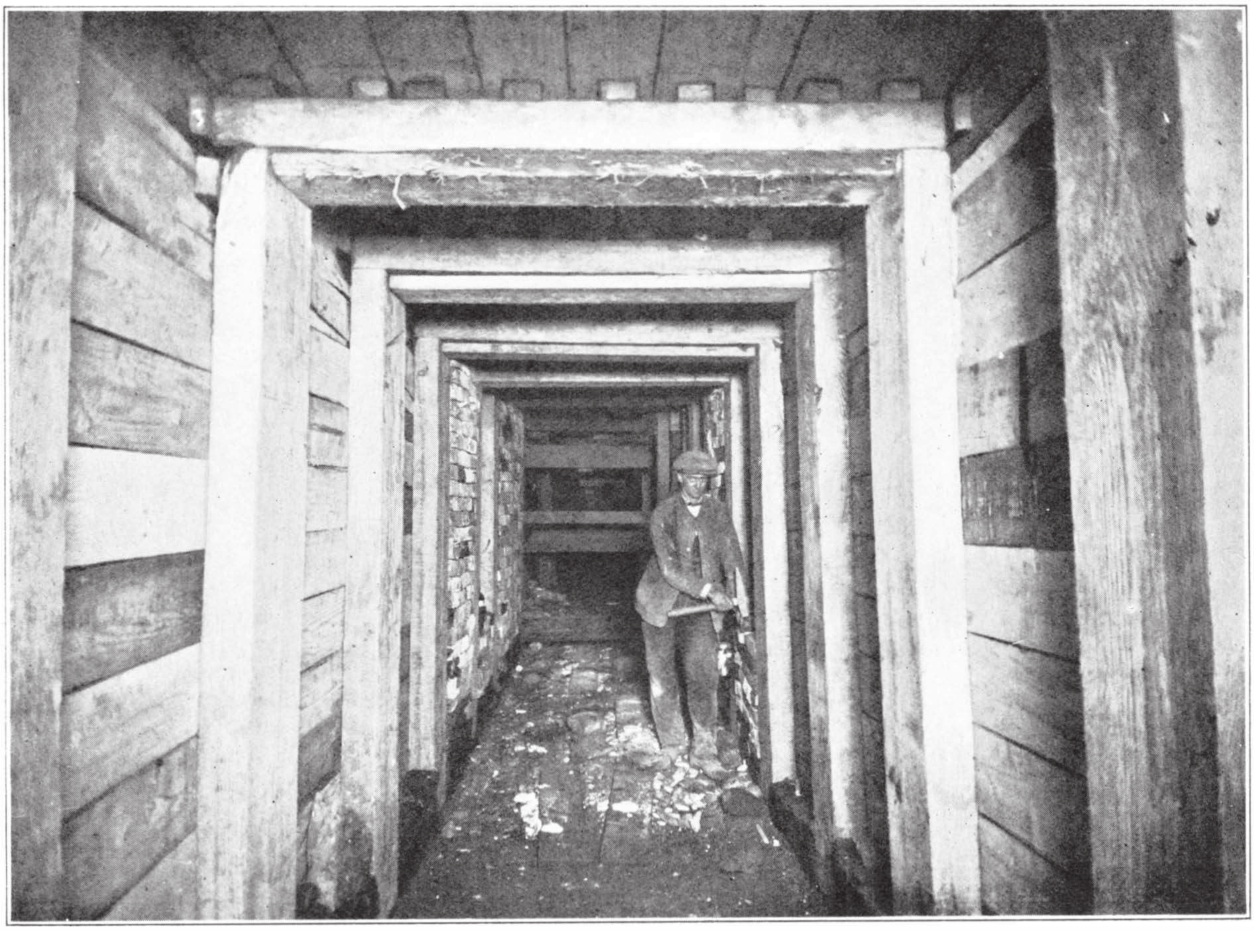


FIG. **8**.—TUNNELLING: PACKING OF SPACING BETWEEN SIDE TREES.

Fig. **11** shows the work on the 70-way duct section in Blackfriars Street in progress. It will be seen that several mains had to be supported in the trench. This necessity frequently arose in the course of the operations. Fig. **12** shows another case of a foreign main supported in one of our headings.

Several large manholes were built in part under tramlines, the excavations ranging up to 16′ in length. In a typical case the affected tramline was carried during the work on a 12″

balk of timber, supported on similar uprights. After completion of the manhole a 9″ wall was built up off the manhole roof to afford permanent support to the rail.

A 77-way section of octagonal ducts was laid under the whole width of the Head Post Office, from Spring Gardens to Brown Street, in a trench cut through the floor of the basement. This device was adopted in consequence of the extreme congestion existing underground in the narrow connecting street.

In Chapel Street and at other points on the various routes, trenches ranging to 15′ in depth had to be excavated very close to high buildings, and extending down to levels below those of the foundations. As at many points the subsoil is loose gravel this work naturally produced some anxious moments. Trench timber of the most substantial description had to be used, and much of this timber was left permanently in position. Further, after the laying of the ducts, the trenches were filled solid with 10 to 1 concrete up to the foundation levels, and above these levels struts of concrete 12″ in width were built across the trenches almost up to the paving levels every few feet. These measures were successful in avoiding damage.

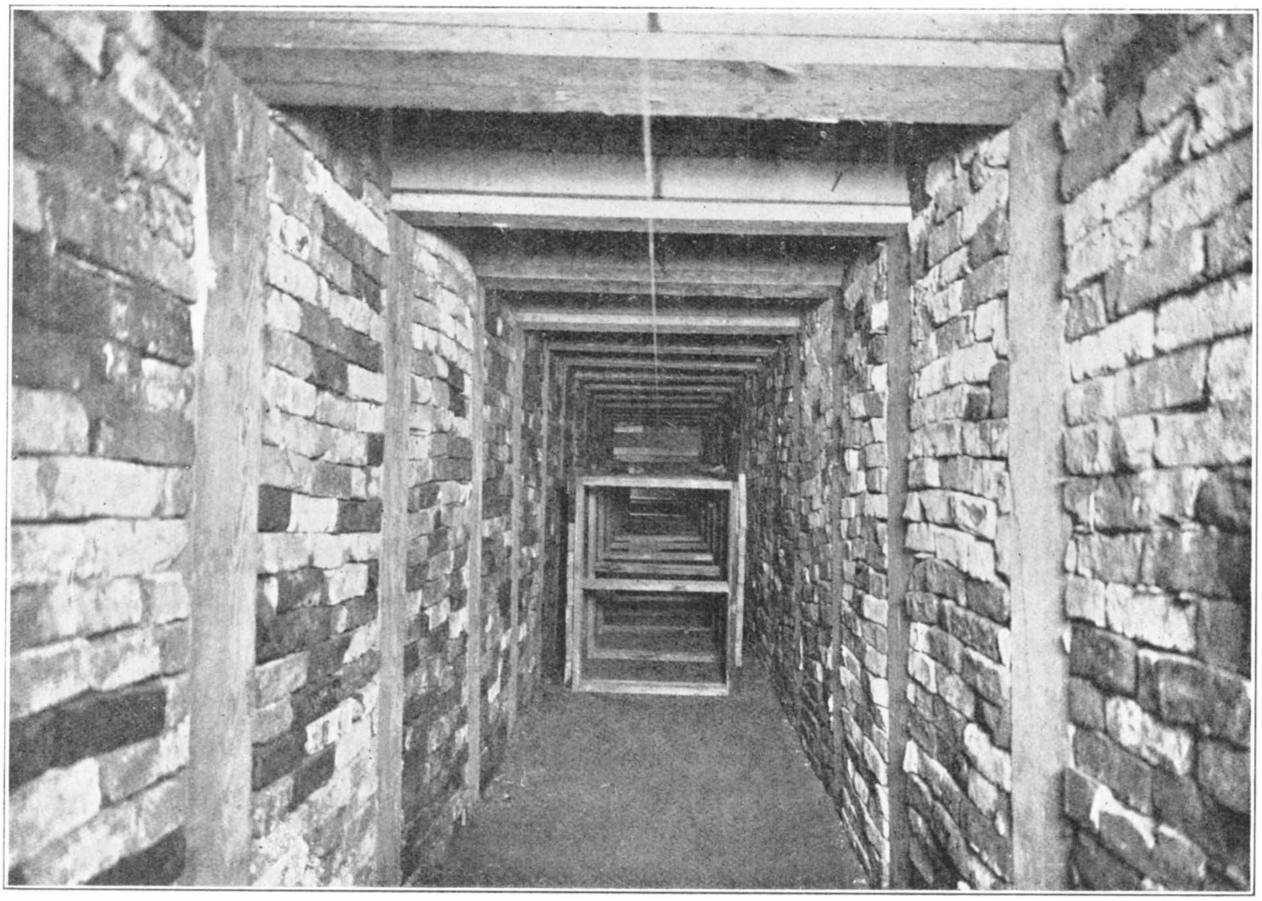


FIG. **9**.—TUNNELLING: FORMERS FOR CONCRETE WALLS IN POSITION.

Fig. **13** shows a somewhat unusual form of construction, *i.e.*, a cable subway about 10 yards long designed to avoid the construction of a manhole, with the consequent necessity for a surface entrance, at an angle in the track located at the junction of two very narrow and congested streets—Parsonage Lane and College Land.

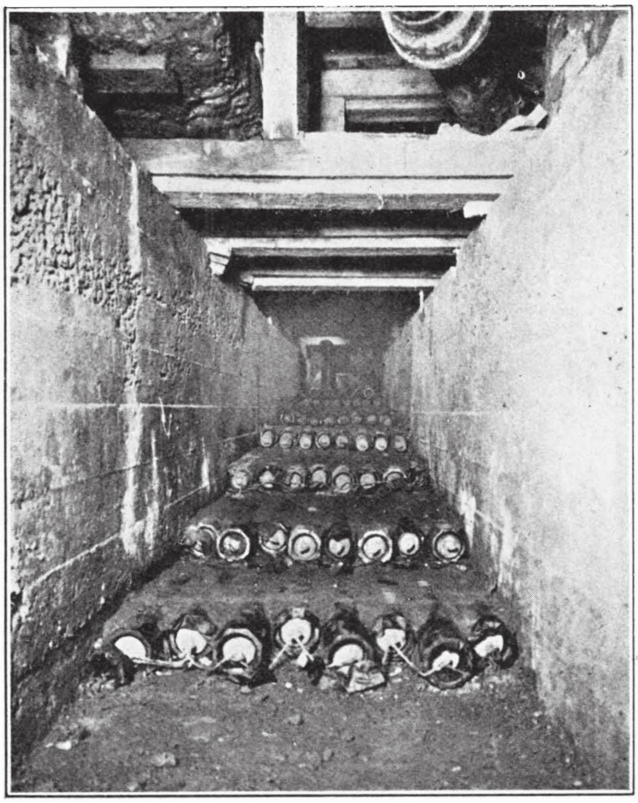


Fig. 10.—Partly constructed Duct-line in Tunnel.

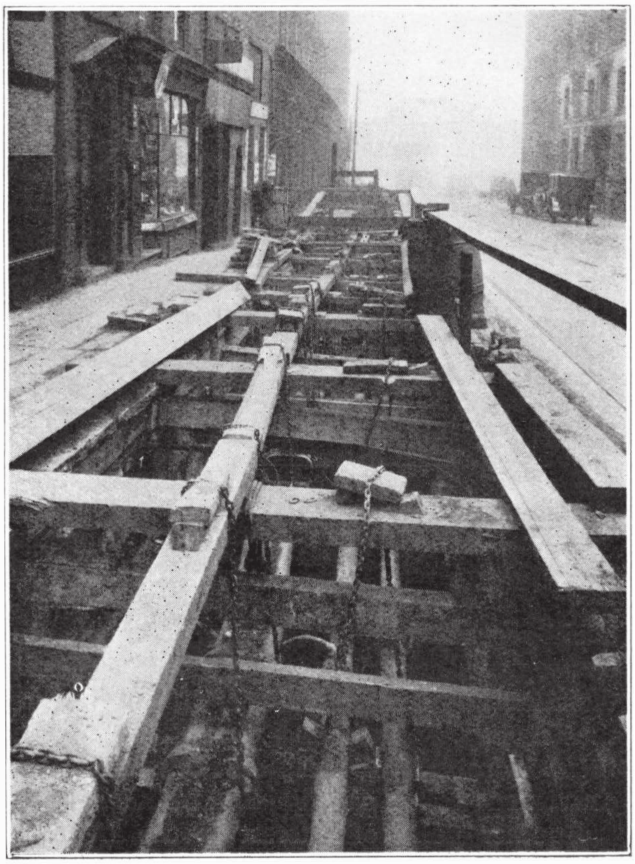


Fig. 11.—Trench for 70-way Duct-line, Blackfriars Street, Salford.

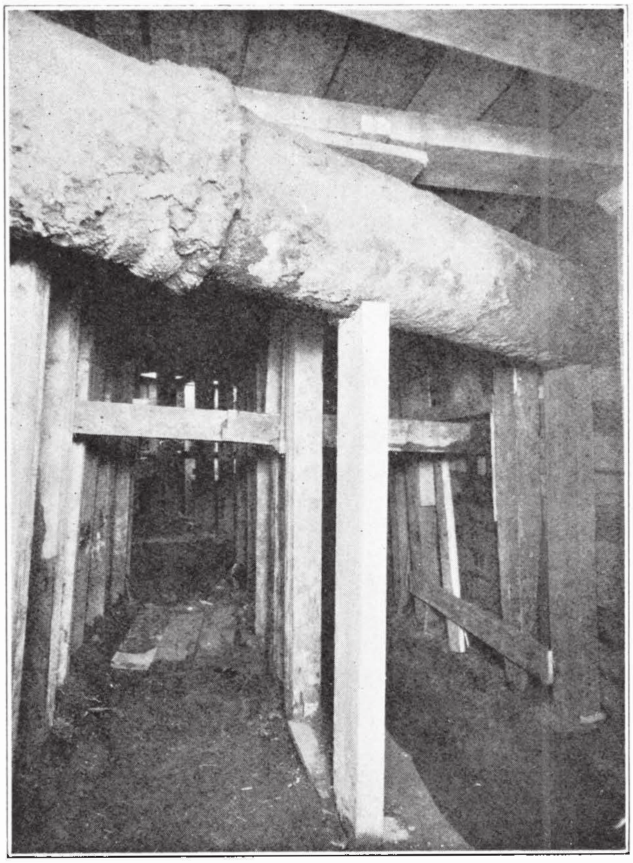


Fig. 12.—Tunnel at junction of Blackfriars Street and Chapel Street.

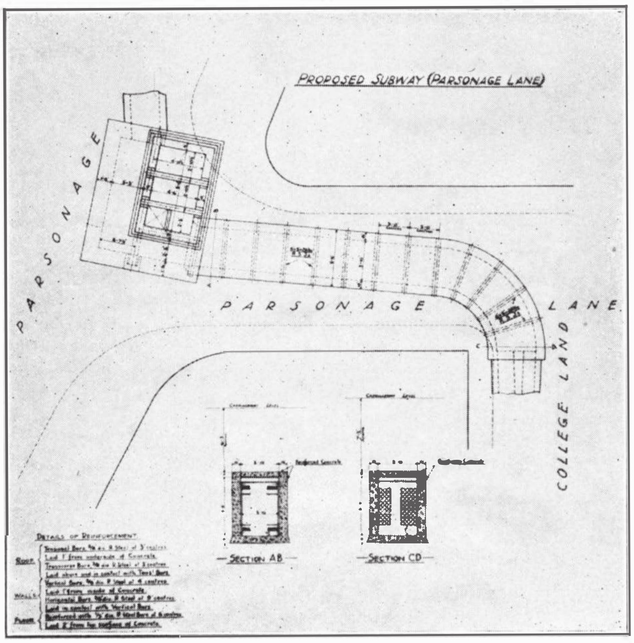


Fig. 13.—Cable Subway.

Cable bearers are provided on the sides of this subway between the ends of the ducts and the manhole in The Parsonage.

One of the most interesting sections of the work was that running along Deansgate, perhaps the most important of the main roads through Manchester. The duct track varies from 66-ways at the Exchange end to 35-ways at the remote end, nearly a mile to the South. Very formidable obstructions were encountered in the section between John Dalton Street and Bridgewater Street, with the result that it was ultimately found necessary to tunnel through solid rock at an average depth of 25′. The depth to the floor level of the John Dalton Street manhole—the deepest manhole constructed in connection with these works—is 37′. At this manhole a change of duct-line level of 14′ had to be effected. The exceptionally deep manholes in this part of the route have usually a cabling entrance in the carriageway, but in order to avoid obstruction to traffic when jointing only is in progress, and also to promote ventilation, there is in most cases a side shaft entrance from the footway. Ventilating pipes have also been fitted in several of these manholes and led to convenient points on adjoining buildings, etc.

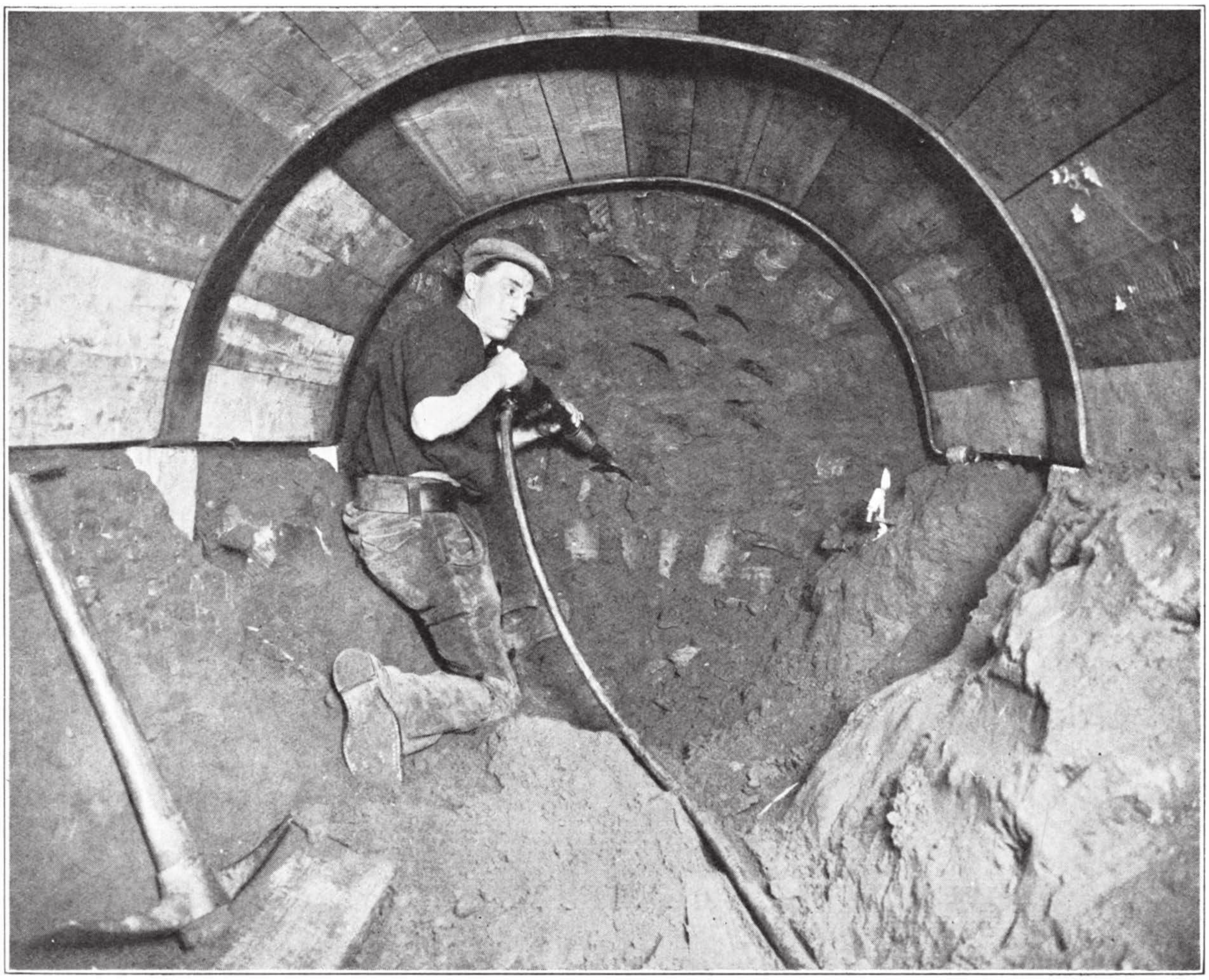


FIG. 14.—TUNNEL UNDER MANCHESTER-ROCHDALE CANAL: EXCAVATING.

Another point of interest in the Deansgate section is the crossing of the Rochdale Canal. Here, owing to innumerable underground obstructions, it was found necessary to effect the crossing by means of a tunnel under the canal. This tunnel was driven in solid rock at a maximum depth of 32′. No serious difficulty was encountered. A similar tunnel under the same canal in the line of Sackville Street was also found necessary, but in this case the tunnel was for the greater part in clay, with a thin seam of sand lying on top of sandstone at the lowest point. In view of the less satisfactory nature of the subsoil here, a circular brick culvert was constructed to contain the ducts, and to afford due support to the canal bottom and to the piers of the Sackville Street Bridge, which crosses the canal at this point. Figs. **14--16** illustrate the construction of this subway.

The manholes built on the main sections of this work number about 70, and their cubical contents approximate to 90,000 cubic feet. Approximately 300,000 yards of single way duct are included in the routes shown in Fig. **1**, *i.e.*, in the more central portions of the scheme.

J. CLEAVER.

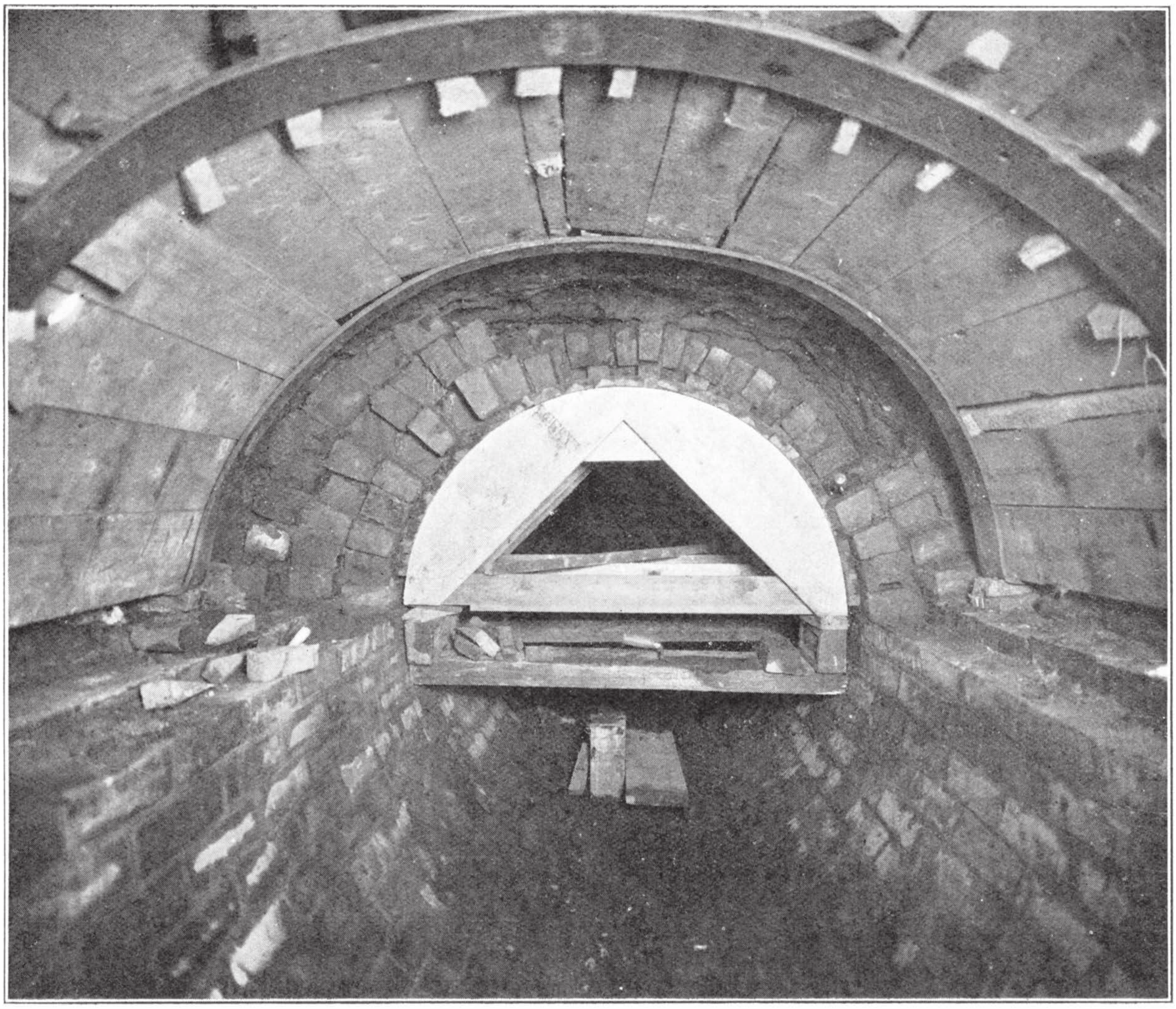


FIG. **15**.—TUNNEL UNDER MANCHESTER-ROCHDALE CANAL: CONSTRUCTION OF BRICK SUBWAY.

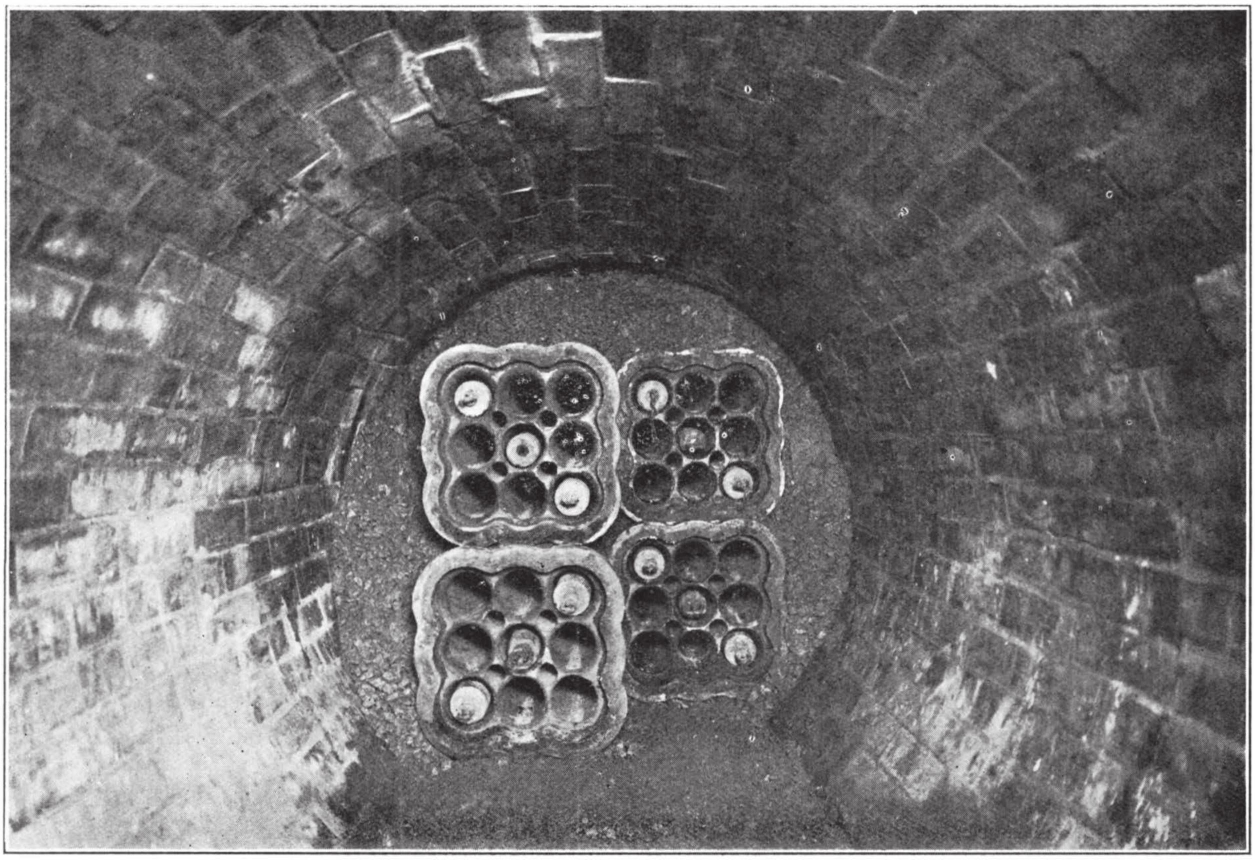


FIG. **16**.—TUNNEL UNDER MANCHESTER-ROCHDALE CANAL: SUBWAY COMPLETED AND DUCT LAYING IN PROGRESS.

MECHANICAL AIDS TO WORKS OF UNDERGROUND CABLING.

CHARLES F. STREET, Assoc.M. Inst.C.E., M.I.E.E.
(Late of Engineer-in-Chief's Office, G.P.O.).

THE article which appeared in the volume of this Journal for October, 1929, under the above title, has no doubt been read with interest by a large number of cable engineers, and the following notes have been prepared as an addendum, stating practices carried out by an undertaking outside the Post Office Service, together with comments upon certain current practices in construction.

The equipment and methods of cabling will, of course, depend upon the required out-put in miles per week and also whether the duct route is in a city or in the open country.

A common rate of progress for cable contracts is thirty to forty lengths per week, *i.e.*, 6—7 lengths per day.

The article describes a bogey capable of carrying one cable drum at a time from the nearest railway station to the manhole site. It would seem that this method of delivery is only suitable for delivery to manholes within, say, three or four miles of the railway station, otherwise it would be difficult to average 5 drums per day without the use of two or more bogeys.

For feeding a route in a busy thoroughfare from a dump or stores which is only a few miles from the route, the low loading type of motor vehicle carrying but one drum has been found quite suitable. It is fairly fast and easily loaded and unloaded.

It is part of the scheme mentioned to pay out the cable without unloading the drum from the bogey, and this is a good scheme in busy thoroughfares. Unless, however, the tractor is also used for drawing in the cable, there is a decided objection to the tractor standing by until the cable drum is emptied. Similarly, with only one bogey, the cable gang must stand by whilst the bogey is collecting another drum of cable.

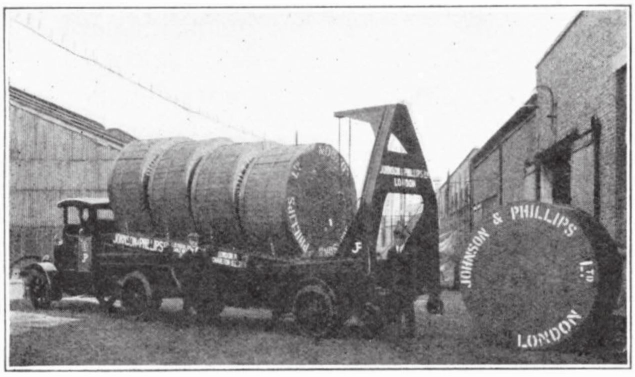


Fig. 1.—J. and P. 6-wheeler.

In the opinion of the writer, the processes of "Cable delivery" and "Drawing in" must be two distinct services.

Regarding the first service, delivery by rail has been abandoned for some years. The objections to the system are that the drums have to be loaded and unloaded three times instead of once, and at some Railway Stations the only handling facility is a "Dock" which necessitates the use of special trucks and man-handling of drums. Trucks with full side flaps are necessary and even then a special disposition of the drums has to be arranged, otherwise the trucks may be loaded with a crane at the sending end and cannot be unloaded by rolling at the receiving end.

The process favoured is to load the cable into special vehicles at the Cable Works, and to deliver them to the precise spot where required for cabling. This process has been employed in cases where manhole sites are two hundred and fifty miles from the Cable Works. For greater distances than this, cable has been sent by sea, and a special vehicle used for delivery from dock to manhole site. The chief drawback to the former system is the return of empty drums, and a heavy accumulation of these on site may occur unless the traffic is properly regulated, and this will require special journeys to collect empty drums, which of course is unprofitable.

Two types of vehicles, capable of carrying up to 10 or 12 tons, have been employed for cable delivery, namely, the J. & P. 6-wheeler and, latterly, the Scammell 8-wheeler. These are shown in the accompanying photographs and are equipped with facilities for loading and unload-

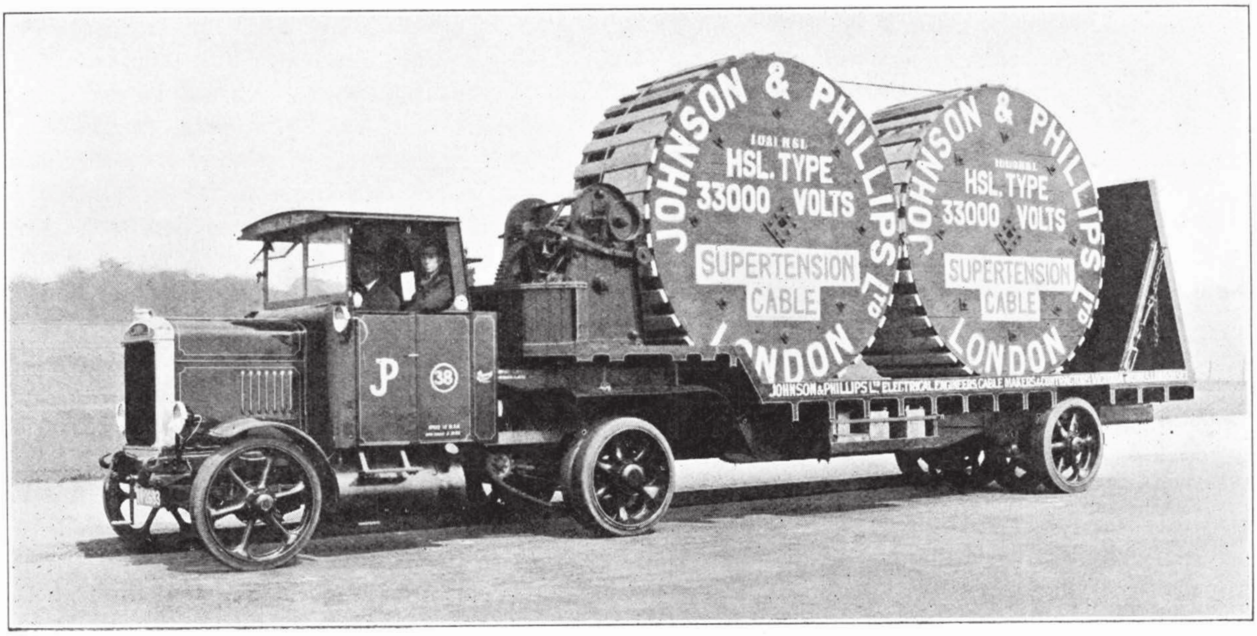


Fig. 2.—Scammell 8-wheeler.

ing of drums. The four-wheeled back axle is to be noted in the case of the latter vehicle.

Regarding the process of drawing in, as the author of the original article points out, it is a common mistake to deal only with the actual hauling of the cable through the ducts by mechanical means. If a programme of five or six lengths per day is to be undertaken, it is also necessary to consider the shifting of the gear and gang by mechanical means. The early forms of motor winches consisted of a motor driven winch mounted on a four-wheel truck, but these winches themselves occupy a considerable amount of time to shift them from one point to another.

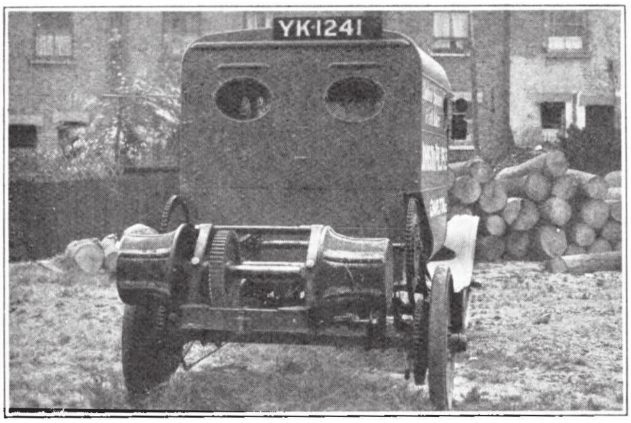


Fig. 3.—J. and P. Cabling Machine.

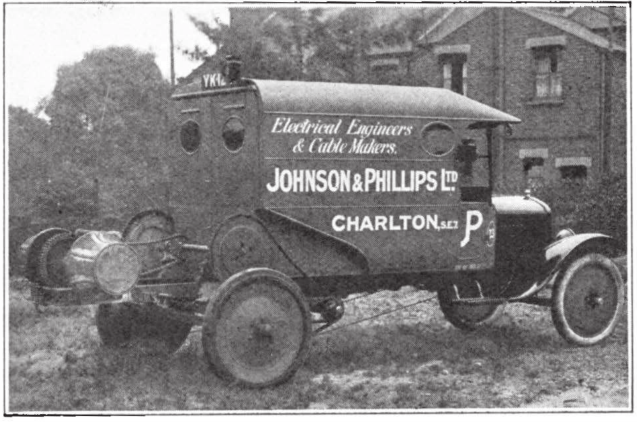


Fig. 4.—Cabling Machine.

Taking five lengths of cable as a normal day's work, it will be appreciated that the shifting of gear and gang represents a very important part of the work, seeing that the time in which cable is in motion is only about 1½ hours for five lengths of cable.

In the opinion of the writer the correct mechanical equipment includes two parts. (*a*) A power unit or Cabling Machine, as it is called, in the form of a lorry which incorporates a winch which can be driven by the same motor as that which propels the lorry, and (*b*) a large four-wheeled trailer with a flat truck body. This carries all the equipment required at the paying-in end of the duct, namely, Screw Jacks, Spindle, Grips, Jelly, etc.

The two vehicles are necessary, and one is stationed at each end of the duct section. When the cable has been drawn in, all the gear and gang are put into the unit at each end of the section and the cabling machine returns to pick up the trailer and tows it to its correct position for the next section to be cabled.

The cabling machine employed is shown in accompanying photograph. It has drawn in over five hundred miles of cable for the G.P.O. and differs from the machine described in the original article in the following respects:—

(1) It is equipped with two bollards mounted on the extremities of a horizontal shaft at rear of the vehicle instead of one bollard or capstan mounted on a vertical shaft in the middle of the floor of the vehicle. This enables a bollard to be placed right over the manhole opening.

(2) In its original form a drum was mounted on the vehicle for the reception of the hauling rope, as shown in the original article. This was soon abandoned as being wrong for the following reasons: When the cable has been drawn into the duct, the rope is then wound on a drum mounted on the vehicle. The rope has next to be drawn into another duct section.

This obviously cannot be done by the cabling machine until the rope has been taken off that vehicle. It could be drawn in by hand, but this requires the effort of four or five men. It has been found better to mount the rope drum on a pair of wheels quite separate from the cabling machine and to tow it from place to place.

(3) The question of a motor driven pump

has also received attention. For this purpose a cylinder-piston pump of the type described in the original article was considered unsuitable owing to the risk of the valves becoming inoperative by stones and dirt. A floodgate or diaphragm pump, with a 2″ delivery pipe, was fitted to the cabling machine. This has a discharge of 800 gallons per hour, and is considered to be too small. A 3″ floodgate pump with a discharge of 3,000 gallons per hour would be adequate, but such a pump is found to be too large and heavy to be fitted as part of the equipment of the cabling machine.

It is perhaps not out of place here to comment on the use of buried jointing boxes. The installation of these used to be governed by the class of the road service above them. Obviously, if the paving is of an expensive type it would be profitable to instal a surface entrance chamber. In arriving at the economical type of chamber to use it must, however, be remembered that in laying a modern trunk cable a number of these boxes have to be opened four times, not once, *i.e.*, at least once for the following operations: Cabling, Testing, Jointing and Pressure testing.

It is thought that four separate openings of the same hole for one cable would almost justify the provision of a surface entrance box for even cheap forms of reinstatement especially if the excavation is difficult. Four openings could always be regarded as necessary at the chamber at the mid-point of a Loading Coil Section.

Buried boxes are provided with concrete slabs for the cover. Each of these slabs has an inverted U shaped piece of iron rod to serve as a handle. These handles are somewhat inconvenient, pick heads catch beneath them when digging. They impede the removal of the soil with a shovel and, moreover, prevent the slabs from being readily brushed before the slabs are removed. This results in dirt being tipped into the jointing chamber. Matters would be improved if this handle were fitted to one slab only. This slab could be removed first and as this exposes the edge of the next slab the necessity for handles on subsequent slabs practically disappears.

Regarding marking posts. One of the first operations for a Cabling Contractor is to identify the marking posts by numbering them.

With balanced cables it is essential that there shall be no mistake about the identity of a jointing point.

This identification must still be necessary during the maintenance of the cable, and it is thought that the points might be permanently numbered by the Department.

It is convenient to allocate a number to a section length and not to a jointing point. This involves the placing of two numbers on a marking post. Thus, three on one side of the post, and four on the other would indicate the junction point of lengths 3 and 4. Loading Sections are indicated by a number. Thus L.C.S. 1 is the section from the starting point to loading point No. 1. By also painting the number of the Loading Section on the tops of the marking post any length of cable can be at once identified. These points may seem elementary, but the making of a selected joint at the wrong place or " upside down " and having to break it down again, soon establishes the necessity for very definite rules on the matter.

Pursuing the question of efficiency of underground construction, the following notes have been prepared regarding the process of jointing.

The jointing of a dry core telephone cable has frequently to be carried out in adverse circumstances. One of the adverse factors is dampness, and some attention has been given to the production of a dry joint.

Laboratory experiments were made to determine the effect of drying and exposure of paper sleeves such as are used for making a joint.

The result is shown in Fig. **5**. From points A—B the sleeves were heated in a tin with the lid removed at a temperature of 275°F. and weighed periodically and the loss of weight noted. From B onwards the source of heat was removed and moisture was re-absorbed.

This Fig. is instructive and indicates two important points, firstly, that paper jointing sleeves as issued by the makers in cardboard boxes require a temperature of 275°F. for 5 hours before they are dry, and, secondly, that the moisture under laboratory conditions at all events is re-absorbed at a much slower rate.

It is clearly undesirable that the five hour drying period should be spent after the sleeves have been used in a joint. For this reason it is now a standard practice that all paper sleeves are dried in the cable ovens for a period of five hours. They are then placed in airtight tins which contain about 120 40lb. sleeves.

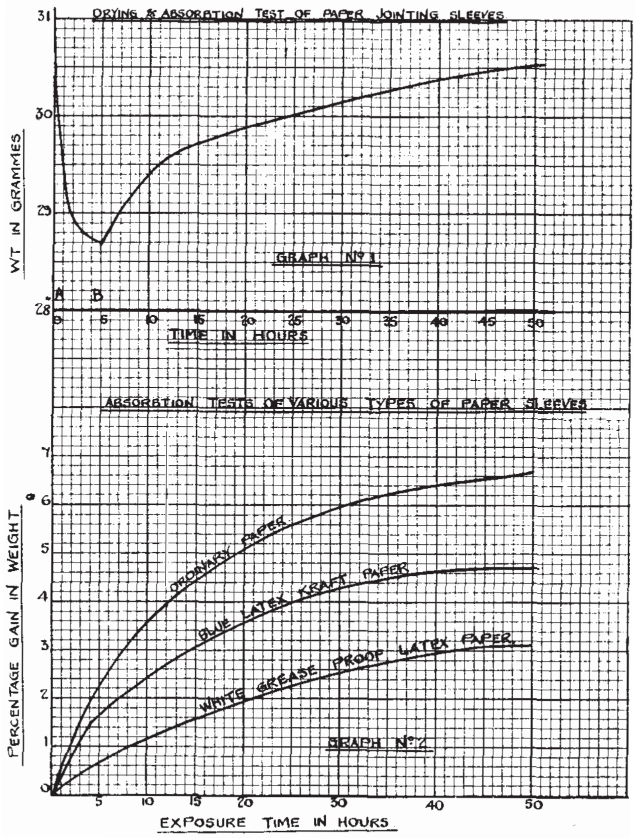


FIG. 5.—GRAPHS 1 AND 2.

The use of tins containing more sleeves would result in a longer period of exposure from the time that the tin is opened until the last sleeve is used. The tins are generally damaged in use and are seldom recovered. The cost of the tin is of the same order as the value of the sleeves which it contains. Nevertheless, it is considered that the practice of drying and issuing sleeves in airtight tins is a sound one.

Before leaving the question of drying paper sleeves it may be of interest to record that absorbtion tests were made with sleeves made with two kinds of rubber latex paper. The result of these tests are shown in Graph 2, Fig. 5.

It will be seen that the ordinary sleeves absorb more moisture in a given time than either of the latex papers, and it seems desirable that this matter should be pursued.

Drying and absorbtion tests similar to those made on paper sleeves were also made with a Ball of Whipping, and a Roll of Insulation Paper, both of the type used for making a telephone cable joint. The general characteristics of the Drying and Absorbtion figures were similar to that obtained with the paper sleeve. The actual weights may be of interest.

	Ball of Whipping.	Roll of Insulation Paper.
Weight before drying	330.55 grams.	1283.109 grams.
Weight after drying (5 hrs.)	311.30 ,,	(7 hrs.) 1193.16 ,,
Weight of moisture expelled	19.25 ,,	89.94 ,,

Complete re-absorbtion did not occur in over 100 hours.

The method adopted in practice with regard to the whipping is to dry it and then place it in a special container. This consists of a lever lid tin with a Dry Air Nozzle sweated over a full-sized hole in the side of a tin. (See Fig. 6).

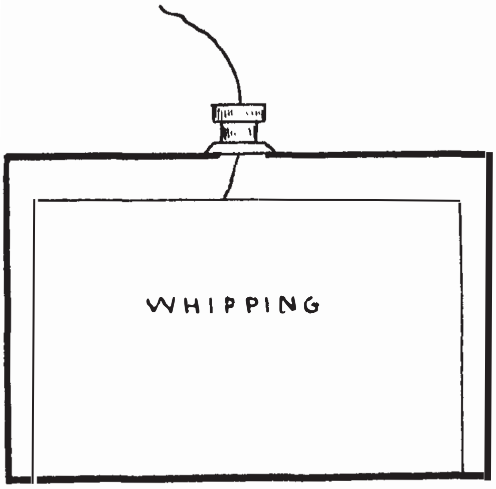


FIG. 6.—WHIPPING CONTAINER.

The end of the whipping is passed through this hole and through a small hole in the cap of the nozzle. The whipping can then be withdrawn as required. When issued, a rubber washer is contained in the cap of the nozzle and the passage of the whipping through the rubber washer makes an excellent airtight joint. In practice, however, the rubber washer has its drawbacks and is frequently discarded. The reason for this is that if the whipping should break it cannot be passed through the washer again without the aid of a needle, which is seldom to be found in a jointer's kit.

The container is, however, quite serviceable without the rubber washer. The same principle is employed in the container for the Insulation Paper. The paper is dried and placed in a large flat tin fitted with a rubber flap covering a slit in the side of the tin. See Fig. **7**. The paper is readily withdrawn through the slit as required.

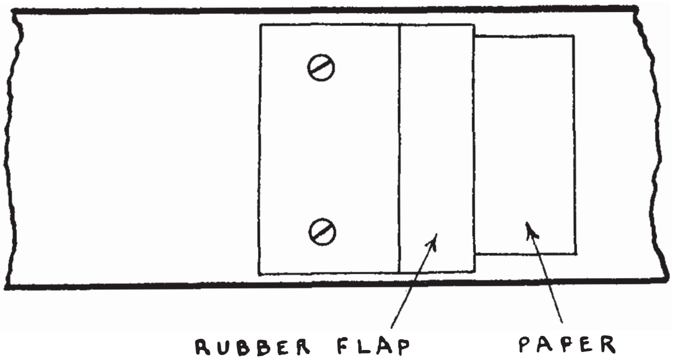


Fig. **7**.—Portion of side of Paper Container.

Another point to which attention has been given, is that of " Drying Out " a joint before the lead sleeves is placed and plumbed in position. There appears to be several types of " Drying Out " trays or ovens in use.

One type consists of a metal case placed over the joint from above and left open on the underside. Lamps are then placed below the oven for the purpose of drying the joint. Criticism is levelled at the principle of these ovens on the ground that the drying process is retarded as damp air from the bottom of the jointing pit arises therefrom and is continually passing through the joint.

The type of appliance favoured by the writer is a tray placed around the joint from below, and a lid placed on from above. Lamps are then applied to the bottom or sides of the tray.

This overcomes the detrimental effect of damp rising through the joint to be dried.

A general view of the Drying Out tray is shown in Fig. **8**.

In order to prevent scorching of the joint a baffle plate is fitted inside the tray to prevent the joint actually touching the tray proper. An inspection door is fitted to the lid.

A series of adjustments were made to the space between the junction of the end of the tray and the lid. This space was made such that with two lamps operating on the side or bottom of the tray the temperature of the joint did not exceed 220°F. This temperature was reached after one and a half hours heating and was not exceeded after the heating was continued for another half hour.

The use of mechanical appliances for actually twisting the wires of a joint have not been successful up to the present, and the jointer has made better progress with his fingers than with any special appliance.

Seeing that telephone cable jointing involves a great amount of repetition work, it would seem to be an excellent subject for the application of motion study. The chief reason for retarding progress in this direction seems to be the variety of positions and conditions in which joints have to be made. One series of operations, however, which can be catered for, is that of putting down the soldering iron after a sweat has been made in a position in which the iron is again heated and ready to be picked up again when required. The reception appliance must be strong, capable of accepting the iron, somewhat roughly, and must not be rickety and liable to fall over.

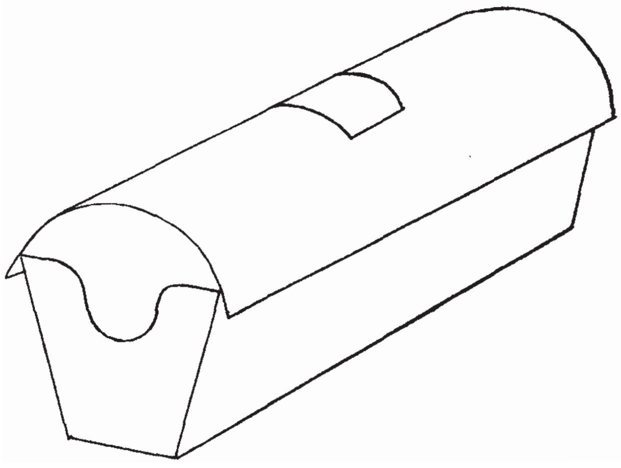


Fig. **8**.—" Drying out " Tray.

Provision for these operations is made in what is known as a Lamp Shade; for in addition to fulfilling the requirements mentioned it also pro-

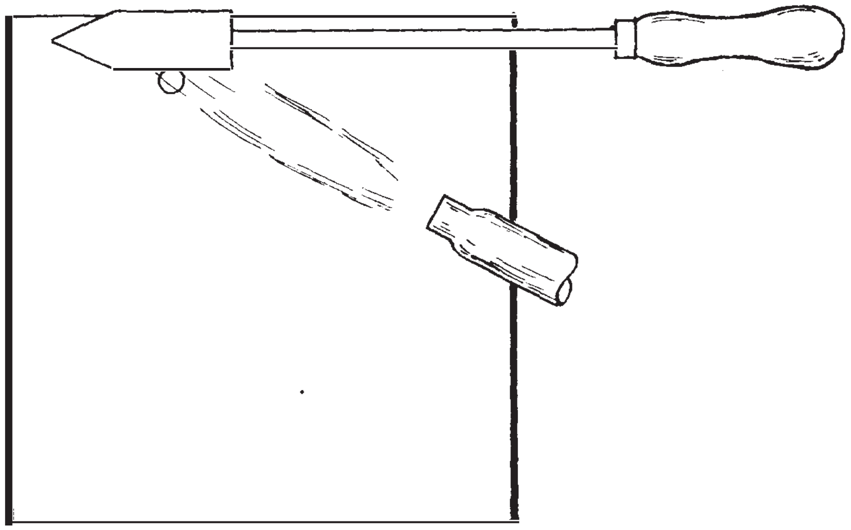
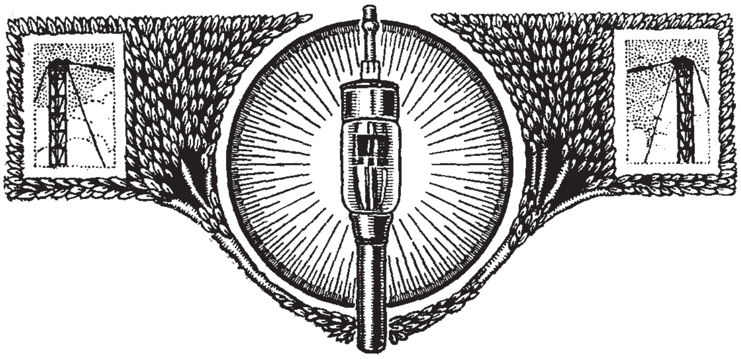
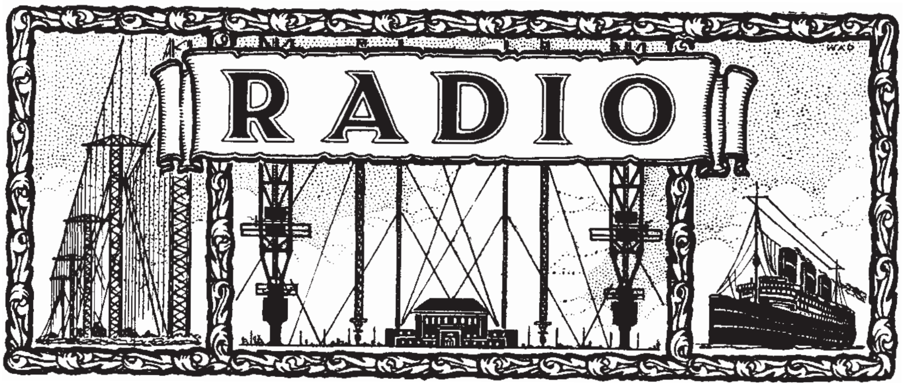


FIG. 9.—LAMP SHADE.

tects the lamp flame from draughts. The Lamp Shade consists merely of a sheet iron box without top or bottom. See Fig. 9. A slot is provided at the side for the insertion of the nozzle of the lamp. The top ledge of the shade is suitably notched for the reception of the iron. This very simple appliance is found to be most serviceable in practice.





THE HAGUE RADIOTELEGRAPHIC CONFERENCE, 1929.

THE International Radiotelegraphic Convention of Washington in 1927 provided for the formation of a Technical Consultative Committee whose duty it would be to consider the various technical problems arising out of the decisions of the Convention.

The functions of the Committee are thus purely of an advisory or recommendatory character. The decisions and recommendations of the Committee, however, cannot fail to have a marked influence on the trend of development of radio in the future, while in the case of unanimous recommendations it is probable that administrations will put these into effect without waiting for the formal endorsement of the next Convention.

The first meeting of this technical committee, known as the Comite Consultatif Technique des Communications Radioelectriques (usually abbreviated to the initials C.C.I.R.), took place at the Hague from September 18th to October 2nd last.

About fifty countries, self-governing colonies and exploiting organisations were represented, and the total number of delegates and experts present exceeded two hundred.

The British delegation consisted of seven members, the chief of the delegation being Lt.-Col. A. G. Lee, Assistant Engineer-in-Chief of the Post Office.

Organisation.—Owing to the fact that this was the first meeting much of the work involved dealt with the organisation of the Committee itself. It was decided not to establish a permanent secretariat nor to appoint commissions of rapporteurs to carry on work after the termination of the main committee, but that the study of any outstanding question should be handed over to a particular nation to deal with, while other nations interested would be at liberty to collaborate in such studies if they desired. In these respects the C.C.I.R. will differ fundamentally from the C.C.I. Telephonique which possesses both a permanent secretariat and commissions.

Definitions.—Other work of the Committee lay in the enunciation of definitions and of methods of rating radio transmitters. Up to the present the rating of a transmitter might mean anything from the power input to the radio frequency power output. Thus a transmitter rated by one manufacturer at, say, 5 K.W., might be identical with that rated by another manufacturer at 20 K.W. Of course this did not matter very much in actual practice, since when one was specifying or purchasing a transmitter one took care to say how the power was to be measured. The disparity between the different methods of rating involved difficulties in the preparation of International lists of stations. It was recommended that, in future, transmitters should be rated by the power supplied to the antenna, measured, either in the antenna itself or by absorbtion in a dummy antenna or by measuring the power at another point in the transmitter and taking into account the efficiency of the intervening circuits. Telegraph transmitters are to be measured with the key down, and telephone transmitters are to be measured on full power with maximum modulation on a single frequency, with the condition that the sum of the modulation harmonics is at least 20 decibels below the fundamental.

Definitions were also laid down regarding the nomenclature of waves or frequencies as follows:—

Low frequencies (long waves) below 100 kc./s. (above 3,000m.).
Medium frequencies (medium waves) 100 to 1,500kc./s. (3,000-200m.).
Medium - high frequencies (intermediate waves) 1,500-6,000kc./s. (200-50m.).
High frequencies (short wave) 6,000-30,000 kc./s. (50-10m.).
Very high frequencies (very short waves) above 30,000kc./s. (below 10m.).

In regard to the measurement of frequency the view was expressed that the national standard of frequency used by administrations should have a precision of at least 1 part in 100,000.

Frequency meters utilised in transmitting stations, if provided with special features such as crystals, thermostats, etc., can at the present time attain a precision of from 2 to 5 parts in 100,000 metres; unprovided with these special features can attain a precision of 1 part in 10,000.

Frequency Tolerance.—The frequency tolerance or permissible divergence of the frequency of a transmitting station from its assigned frequency was the subject of consideration by the Committee which drew up two lists of tolerances, one immediately applicable and a more stringent list for the near future. On long waves, both lists are identical, being ± 0.1% for fixed and land stations and ± 0.5% for mobile stations. In the latter case the limit only exists during a single transmission, as a mobile station has a right to change its wave-length within its allocated band.

Broadcasting stations on the 200 metres to 545 metres band were limited to ± 300 cycles per sec. immediately and ± 50 cycles per sec. in the future.

On the 200 metres to 50 metres band, fixed stations were limited to ± 0.05% immediately and ± 0.02% in the future. Land stations were limited to ± 0.1% and ± 0.02%, while mobile stations and low power (not exceeding 250 watts in antenna) fixed and land stations working in the shared bands were permitted a tolerance of ± 5 Kilocycles per sec. present and future during a transmission.

On the short waves of 50 metres to 13 metres, the tolerances for fixed stations are ± 0.05% and ± 0.01%, for land stations ± 0.10% and ± 0.02%, and for mobile and low power fixed and land stations 10 Kilocycles per sec. for the present and 5 Kilocycles per sec. for the future, the latter figures applying during a transmission only and in the case of land and fixed stations when working in the shared bands.

The effect of these recommendations will be to compel all low power short wave stations unequipped with precision frequency control to work in the shared fixed and mobile bands, and thus leave the fixed service bands clear for the better equipped high power stations.

Channelling Scheme.—One of the subjects on the agenda was the question of dividing the frequency spectrum into a definite number of frequency channels. Owing to the rapidly changing technique it was considered inadvisable to proceed with the question. In order to promote orderliness in the allocation of wave-lengths, however, it was recommended that administration should allocate frequencies above 6,000 Kilocycles per sec. in definite multiples of 5 Kilocycles.

In allocating frequencies, it was recommended that 6,000 to 23,000 Kilocycles per sec. (50 metres to 13 metres) should be reserved for long distance communication, but that 6,000 to 9,000 Kilocycles per sec. (50 to 33 metres) could be used for medium distance communication in daylight. Frequencies of 6,000 to 3,500 Kilocycles per sec. (50 to 85 metres) should be reserved for medium distance working and 3,500 to 1,500 Kilocycles per sec. (85 to 200 metres) reserved for short distance working.

Prevention of Interference.—On the question of the suppression of unessential emissions by transmitting stations it is interesting to record that the Committee accepted a document submitted by the British delegation as furnishing a sufficiently detailed exploration of the problem. It was decided that it was impossible to draw up regulations on the subject at the present time.

Limit of Power Broadcasting Stations.—The Committee recommended that European broadcasting stations using the band of frequencies 550 to 1,500 Kilocycles per sec. (545 to 200 metres), with the exception of Russian stations, should be limited provisionally to a power of the order of a hundred kilowatts. The words used in the French text are " une centaine de kilowatts " which does not definitely limit the power to a hundred kilowatts but to something between a hundred and a hundred and twenty kilowatts. As this is the power to the antenna, the limit is a generous one and well beyond the power of any existing or contemplated station.

General.—As all the decisions of the Committee were unanimous, and often the compromise between different opposing interests, the results of the first meeting of the C.C.I.R. may be regarded as highly satisfactory.

The Committee decided to accept the invitation of the Danish Government to hold the next meeting at Copenhagen in 1931.

RADIO TELEGRAPH RECEIVERS.

A. J. Gill and G. H. Farnes.

IT may be of interest to give a brief description of two radio telegraph receivers recently constructed at the Dollis Hill Experimental Station, as furnishing an indication of the present trend of development in such apparatus. The complexity of radio receivers has increased to such an extent during the last few years that it has been found necessary to abandon the more familiar type of construction in which a complete receiver is mounted in a wooden case with an ebonite panel containing the controls. The use of high amplification made screening between stages necessary, while ebonite, because of its tendency to warp and surface deterioration, was not entirely satisfactory as a mounting medium.

As a result all modern receivers have been built on the lines of telephone repeater equipment, the apparatus being mounted on metal panels and the panels assembled vertically on steel racks of the same dimensions as standard repeater racks.

The panels used are of cast aluminium alloy and are machined on the front surfaces and edges. They are provided at the back with a cast register which is also machined. A metal screening and dust cover fits over the register and is held on by spring clips.

The switchboard type of construction has proved to be the only possible means of mounting a large receiving set. Whereas ten years ago the largest receiving set had a panel surface of three or four square feet a fully equipped short-wave radio telephone receiver at the present day has a panel area of about 70 square feet!

The assembly shown in Fig. 1 consists of four monitoring long-wave receivers for the Central Radio Office, London. As these receivers have to receive the outgoing signals from the radio transmitters at Rugby and Leafield (which are remote controlled from London) a high sensitivity was not essential.

The four receivers are mounted on two standard racks and have a common meter panel for measuring any filament voltage or anode current.

Each receiver consists of a tuned coupled aerial circuit, a tuned-anode, tuned-grid oscillating detector valve operating on anode bend detection and three low frequency stages. A note filter is incorporated between the second and third low-frequency stages giving a choice of three audio frequency notes of the order of 800 cycles, 1000 cycles and 1200 cycles.

The output from each receiver is fed *via* an output transformer to a distribution board from whence it can be plugged to any position on the control bench for operating a loud-speaker.

As there is always a temptation to anybody to twist the knobs on a radio receiver, and as it was very desirable in this case that the receivers should be always ready for use, it was decided to place all the tuning controls under lock and key. The aerial grid and anode controls are placed

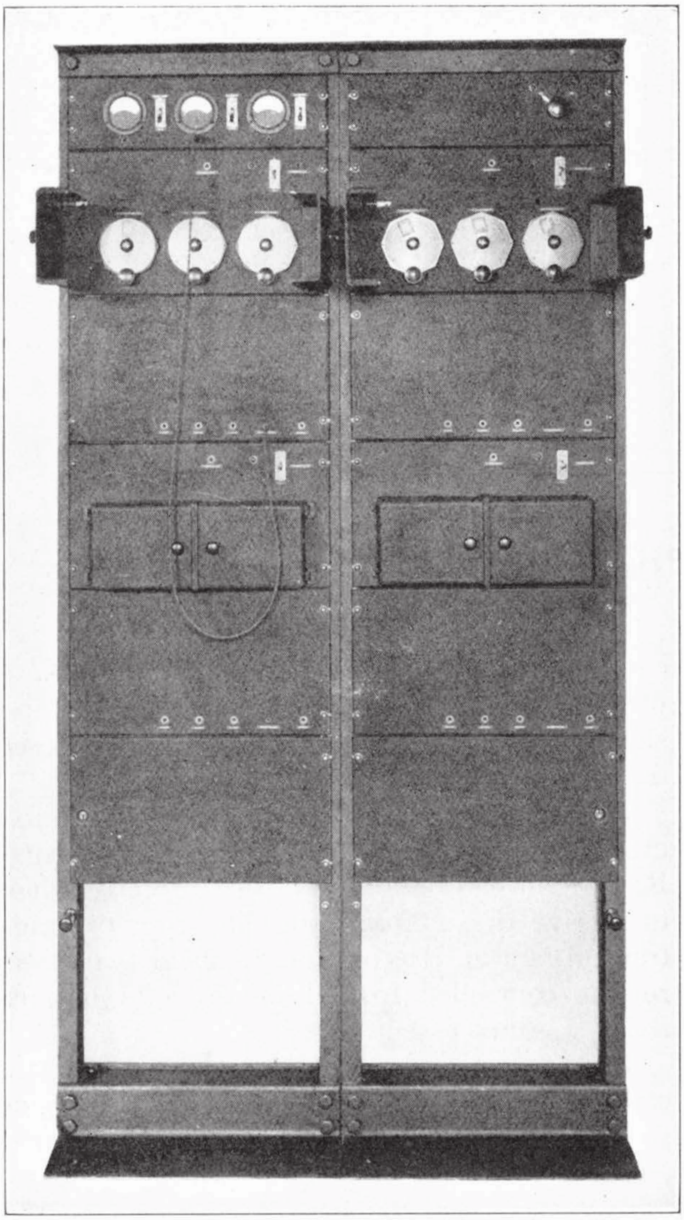


FIG. 1.—MONITORING SETS FOR C.R.O.

under hinged covers which can be locked by the handles at the bottom of each rack. The covers at the back of the receiver can be locked in the same way.

The other receiver, Fig. **2** and Fig. **3**, is of a more sensitive type and is intended for general observation work at the Wick Radio Station, where commercial traffic does not engage the full time of the staff.

The range of the receiver is from 300 metres to 20,000 metres, and this range is covered by means of three sets of plug-in coils, as follows:—Range A covers 20,000 to 6,000 metres, Range B covers 6,000 to 2,000 metres and Range C covers from 2,000 metres to 300 metres.

Looking at the back of the receiver, Fig. **3**, the various panels are as follows:—Left rack, top, spare valves, coil box, heterodyne oscillator, note filter and recorder. Right rack, top, meter panel, aerial tuning panel, high-frequency amplifier panel, detector and low-frequency amplifier panel.

The set consists of two high-frequency stages, using screened grid valves, a separate heterodyne oscillator working on the tuned anode-tuned grid circuit, anode bend detector, three low-frequency amplifier stages and final detector for recording signals on a Wheatstone receiver.

A note filter circuit is incorporated between the second and third low-frequency amplifier and a monitoring circuit is provided after the third low-frequency stage to enable signals to be received on telephones. The loading coil used

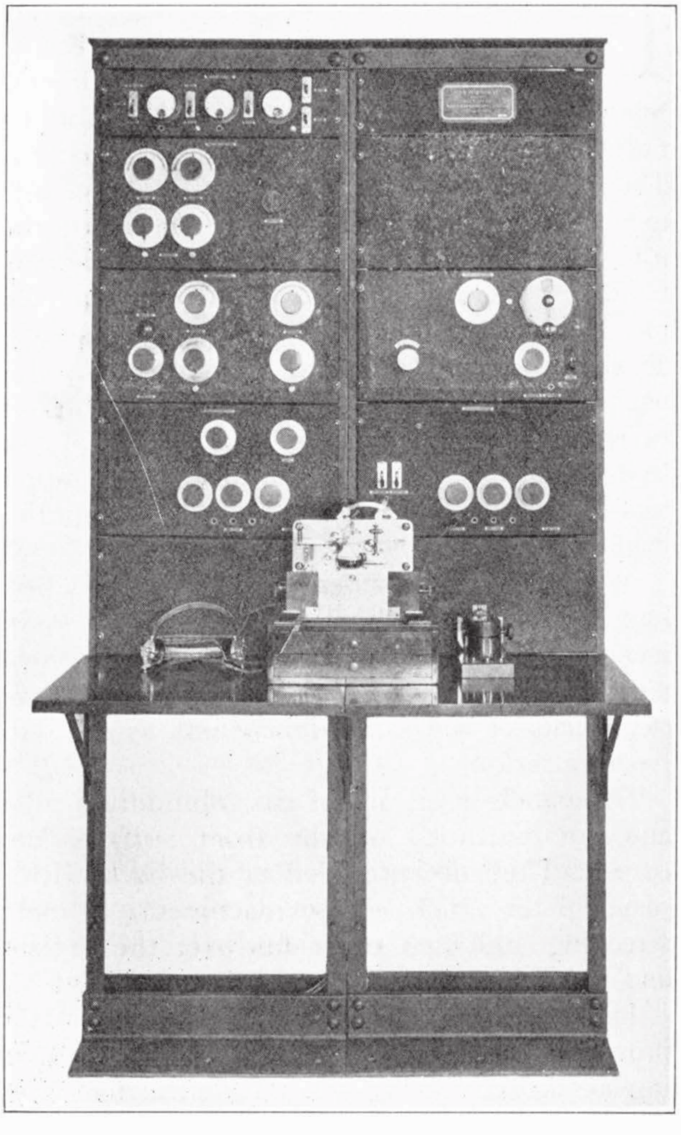


FIG. **2**.—WICK INTERCEPTION RECEIVER. FRONT.

on the note circuit filter can be seen on the bottom left panel, Fig. **3**.

The aerial tuning panel contains a tuned aerial circuit coupled to a second tuned circuit which is connected across the grid filament circuit of the first screened grid valve. The anode circuits of both screened grid valves are tuned so that in order to set the receiver to any wave it is necessary to adjust five different circuits, including the heterodyne. This is not so simple as the one knob control met with on many modern broadcast receivers, but the selectivity and sensitivity is much improved, while tables giving the settings for different wave-lengths have been prepared and facilitate tuning.

The two high-frequency stages are screened one from the other by a cast aluminium partition. Each screened grid valve is mounted in a copper pot and the anode connection projects in proximity to the tuned circuit to which it is connected. The grid circuit connections are brought into the pot through copper screening tubes.

The long ranges on each set of coils have been obtained by providing fixed condensers connected to dial switches which extend the range of the variable condensers fitted.

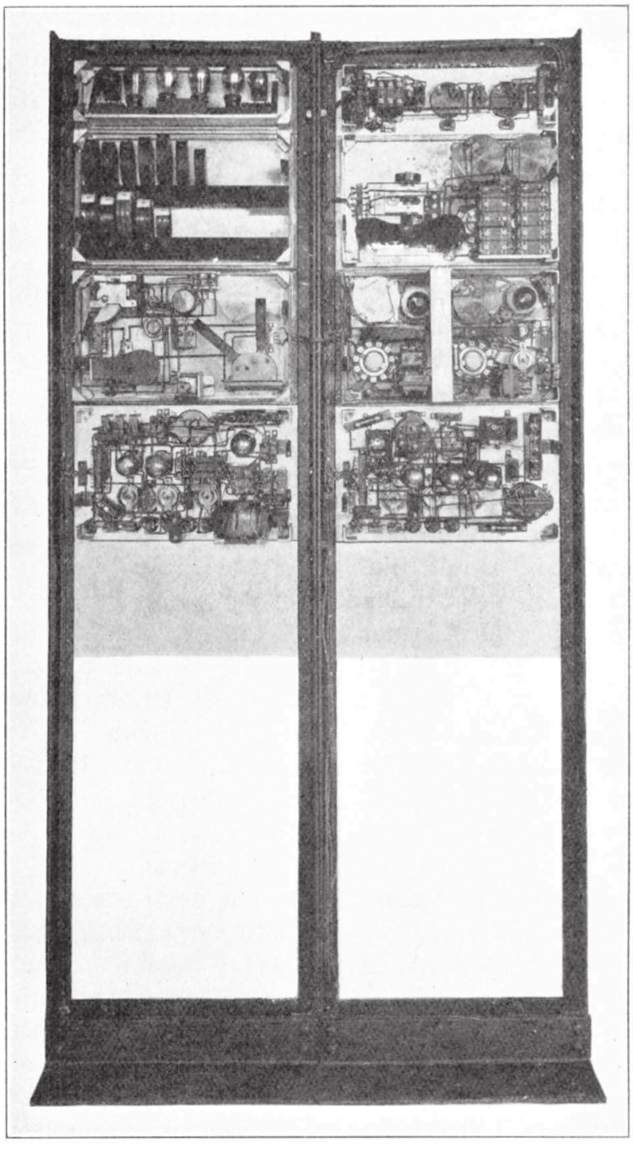


FIG. 3.—WICK INTERCEPTION RECEIVER. BACK.

NOTES & COMMENTS

We give elsewhere in this issue a summary of the Inaugural Address of Col. Sir T. F. Purves, Engineer-in-Chief, in his capacity as President of the Institution of Electrical Engineers, and also a description of the methods employed in broadcasting the address by Trunk lines to the various Local Centres of the Institution. Although many officers of the Department will receive copies of the address in due course when it appears verbatim in the Journal of the Institution, the Board of Editors of this Journal considers that a wider circulation would serve a good purpose and we have accordingly obtained a limited supply of advance copies from the Institution. The Council of the I.E.E. has given us permission to distribute the copies among our readers, and those members of the staff who would like copies should apply to their local agent, or direct to the Managing Editor, E.-in-C.'s Office, Alder House.

By the death of Dr. Hansford the Institution of Post Office Electrical Engineers has lost an energetic and very capable secretary, the Department one of its best and most promising officers and the Journal one of its most enthusiastic supporters and constructive critics. We commend the attention of our readers to the memoir which appears in this issue from the pen of one of his earliest friends and colleagues in the Department.

Our attention has been directed to two errors that appeared in the October issue. The first was in the article on " A New C.B. Microtelephone." On page 188, the last column in the table under the heading Head Horizontal should read :—

Not tested.
16% W
3% W
4% W
———
8% W
———

The second mistake appeared in the article on " The Mechanical Testing of Transmitter and Receiver Efficiencies." On page 193, line 18 of the second column should read " ranges from 600 to 1600 cycles per second at 250."

BROADCASTING IN CANADA.

ROYAL COMMISSION REPORTS IN FAVOUR OF PUBLIC OWNERSHIP.

The Report of the Royal Commission on Radio Broadcasting in Canada, which has just been issued, recommends the establishment of a Government-owned Company, to be known as the Canadian Radio Broadcasting Company, which would be to control and operate stations throughout Canada for the organisation of wireless programmes.

The Board of Directors of the proposed Company, it is suggested, should be composed of twelve members, three more particularly representing the Dominion Government, and one representing each of the Provinces. The Royal Commission recommends that broadcasting should be carried on as a public service; that a Provincial Radio Broadcasting Director should be appointed to control the preparation and transmission of programmes in that area, and that a Provincial Advisory Council on Radio Broadcasting should be set up in each Province.

If the Report should be adopted, seven high-power radio stations would be erected in Canada to provide the service initially suggested by the Radio Commission. These would be 50,000-watt stations, and supplementary stations of lower power would, if necessary, be erected in local areas not effectively covered by the main stations. The estimated cost of the main stations is $3,000,000, and of the smaller units $250,000, and the estimated cost of operating the entire organisation is $2,500,000 annually.

The Commission recommends that, pending the inauguration and completion of the proposed system, provisional services should be provided through certain existing stations. Compensation to the owners of existing stations should be met out of an appropriation made by Parliament, but expenditures necessary for the operation and maintenance of the proposed broadcasting services should be made out of revenue from license fees and advertising rentals, supplemented by a Dominion Government subsidy. License fees for receiving sets would be increased from $1 to $3 a year, bringing in approximately $900,000 per annum, in addition to $700,000 being the revenue expected from indirect advertising. A Federal Government Grant of $1,000,000 annually is recommended to make up the deficiency between revenue and cost of operation.

Legislation will be necessary to implement the recommendations of the Radio Commission, if decided on by the Federal and Provincial Governments. It is understood that the Provinces are ready and willing to enter into negotiations with the Federal Government with a view to collaboration.

The Board of Editors has decided to issue the Index of Contents for the current Volume as an insert in the April issue. In future the Index for the volume will be bound in the January issue, the last number of each volume.

HEADQUARTER'S NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed :—

Exchange.	Type.	No. of Lines
Ardwick	New Auto.	3050
B'ham Northern (Advance)	,,	Main Frame
Flaxman	,,	9900
Haxby	,,	100
Hendon	,,	3100
Ilford	,,	2850
Metropolitan	,,	9500
Mumbles	,,	570
National	,,	9400
Western	,,	6800
Burslem	Auto Extn.	250
Epsom	,,	300
Exeter	,,	760
Foleshill	,,	100
Longton	,,	100
Newcastle-on-Tyne	,,	160
Stockport	,,	360
Stoke	,,	110
Bourne End	New Manual	880
Eghorn	,,	780
Emberbrook	,,	1700
Stanmore	,,	560
Cantebury	Manual Extensions	700
Crosby Extn.	,,	900
Cerebos Salt	P.A.B.X.	30
Hunt & Winterbotham	,,	20
Hyde Co-op.	,,	20
Preston Co-op.	,,	30
Shell Mex (Brixton)	,,	30
Waring & Gillow	,,	Re-arrangement

Orders have been placed for the following works :—

Exchange.	Type.	No. of Lines
Terminus	New Auto	Main Frame
Whitehall	,,	7000
Basford	Auto Extn.	570
Headington	,,	200
Rochdale	,,	Modfn.
Southend	,,	Obsn. Desk.
Whitworth	,,	100
Hindhead	New Manual	650
Merrylee	,,	1600
Morecambe	,,	1080
Scotstoun	,,	2200
Silverthorne	,,	1660
Didsbury	Manual Extensions.	900
Popesgrove	,,	1040
Rockferry	,,	1420
Woking	,,	400
Airworks, Ltd.	P.A.B.X's.	20
Bond Worth & Son	,,	30
Clark & Son	,,	30
Decca Gramophone Co.	,,	30
Horlicks Malted Milk	,,	30
Lanarkshire County Council	,,	30
Lighting Trades	,,	30
Mickley Coal Co.	,,	20
Shell Mex (Brixton)	,,	30
Waring & Gillow	,,	Re-arrangements
Wellsteeds, Ltd.	,,	30

RICHARD VERNON HANSFORD.

The sad tidings that Dr. R. V. Hansford had died as the result of a slip on the staircase of his home, as he was about to leave for the office on the morning of October 5th, came as a shock almost without precedent in the annals of the Engineer-in-Chief's Office. The blow fell with staggering effect upon his colleagues in the Radio Section, and the men who had striven and laboured with him to place Post Office radio in a position of honour in the world of communication engineering found it difficult to realise that Hansford had left them for ever. His death at the early age of 41 years has taken from our midst an officer of outstanding ability and charming personality, and has left an ache in the hearts of his friends which not even time will completely heal. Physically not robust, he brimmed over with life and energy and he proceeded from one task to another, from one triumph to another, with little interest in past successes but with his eyes always fixed upon a new goal and an unshakeable faith in his ability to reach it by the shortest path. He worked for sheer love of work and with an entire lack of self-interest or self-aggrandisement.

Hansford entered the engineering profession by obtaining first position in an examination for apprenticeship in H.M. Dockyard, Chatham. He served the full period of six years, but towards the end he won a Kent County Council Major Scholarship and was granted leave of absence by the Admiralty to enable him to study at the University of Glasgow. There he obtained prizes in the Departments of Natural Philosophy, Mathematics and Engineering, and he was awarded the George Young Bursary for the best record in the First Science Examination. He graduated in 1910 as B.Sc. in Naval Architecture with Special Distinction in Mathematics, Natural Philosophy and Physical Laboratory, and Engineering. After graduating he was awarded the James Watt Research Scholarship, but resigned it to take up an appointment as Second Class Engineer in the Post Office Engineering Department. He had casually applied for nomination to compete for this post, merely because the examination appeared to be one which he could take in his stride, but almost before he realised the extent of the change in his career he had left shipbuilding behind and was attacking the problems of communication engineering and mastering the somewhat complicated organisation of a department which carries out work in every town and village and on or under nearly every road in the Kingdom.

After a short period of training, Hansford took up duty in Edinburgh, serving in that City about a year, partly in Edinburgh Section and partly in the District Office. He was then transferred to Inverness. The writer met him for the first time on his arrival there in August, 1912. After mutual introductions, Hansford proceeded to explain, with his inimitable laugh and without any trace of feeling, that his presence was due to his " own silly mistake." He had applied for transfer to London and had been sent to Inverness. With his eighteen months' experience of the ways of a Government Department he ought to have known that he should have applied for Inverness if he wanted to go to London. The incident is slight, but it is typical of Hansford's outlook of life. He invariably treated his personal disappointments lightly, humorously and with the laugh against himself. Something gone wrong was something to be put right and not something to be complained about.

The war years found Hansford bearing his share of the national burden in strenuous work to provide naval and military communications in the north of Scotland. The telephoning of Scapa Flow and Cromarty Firth, with their huge temporary populations, the erection of an extensive coastal system of look-out lines on the mainland, and in the Orkneys, Shetlands and Hebrides, continual changes and extensions as the war developed, and latterly the provision of communications for the American mining bases and fleet, with some hundreds of lesser works, more than fully occupied the sectional staff, reduced by the demands of war in other directions, and the frequent temporary additions made to it from other districts. In these early efforts Hansford showed the same thoroughness and accuracy which characterised his work to the end. A date named for the completion of a job was a date to be adhered to, whatever the foreseen or unforeseen difficulties. In country devoid of transport facilities and of living accommodation for the men, unforeseen difficulties were by no means unusual or slight, and any sigh of relief at being " over the peak " was usually stifled by the sight of a stiffer peak ahead.

In August, 1919, Hansford left Inverness and joined the Radio Section at the Head Office. It was here that he found the work for which he will be remembered. A wiser selection for service in a new and rapidly developing branch of engineering could not have been made, for Hansford was by nature and temperament a pioneer, with little interest in trodden paths, but ready and able to cut a way for himself, and others, in the untracked and the unknown. The art of valve radio transmission was an entirely new field for exploration at this time and Hansford entered it with all his immense enthusiasm. Experiments at Caister and Stonehaven were followed up by the erection at these stations of transmitters using air-cooled valves. Stonehaven remained in successful operation for Continental traffic until a few months ago, when it was closed for reasons of policy. In 1923, the high-power transmitter for Rugby was in view, and advantage was taken of the building of the Northolt valve transmitter to try, on a comparatively small scale, the methods to be applied to the larger scheme. Northolt is a 30-kilowatt transmitter, using three 10-kilowatt water-cooled valves in the output stage. Rugby with its 54 valves of the same type followed; nothing on so large a scale had previously been attempted, and the task was one requiring professional courage as well as professional skill. Hansford, with H. Faulkner collaborating, was mainly responsible for the design in detail, construction and testing of the transmitter itself, the huge mast system and power plant falling to other members of the little band of engineers who laboured unitedly at what, having regard to its pioneer character, was perhaps the most onerous single effort ever undertaken by the Post Office Engineering Department. Rugby has been visited by radio engineers from all parts of the world, and although the policy which led to the building of the station may have been criticised, not always fairly, there has been nothing but praise and admiration for its engineering design and lay-out.

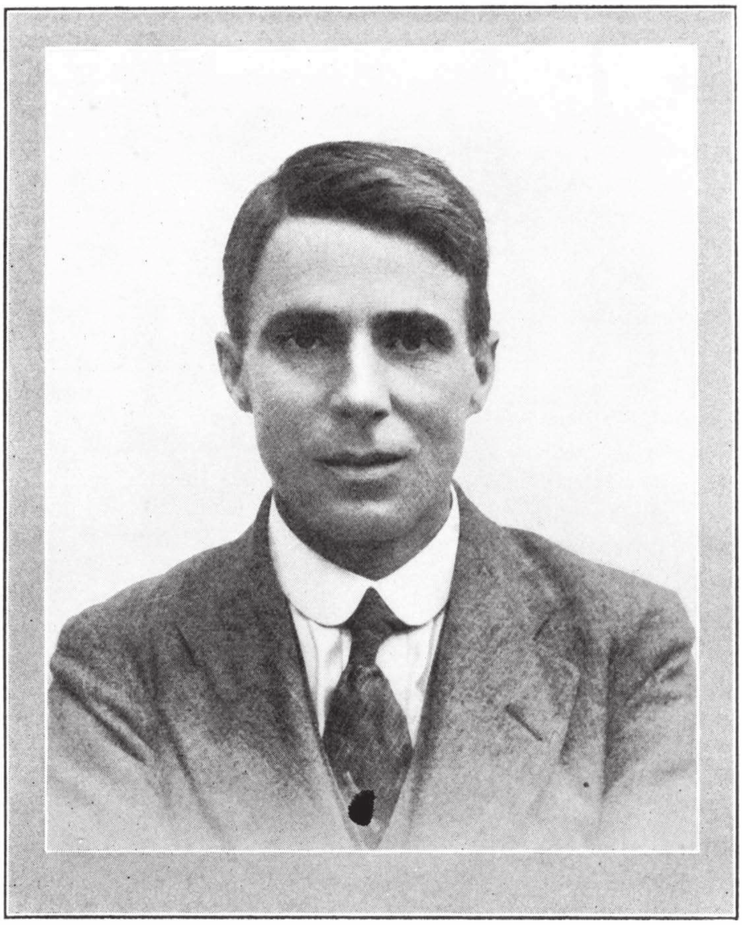
Hansford was also intimately concerned in the inauguration and development of the Anglo-American telephone service, and its extension to the continent of Europe. The main problem to be solved in designing such a service was not so much the transmission of speech across the Atlantic, as the devising of equipment for speaking in both directions on the same wave-length, and for translation to the land line telephone systems at each end of the radio link. The long-wave channel with which the service opened was followed quickly by the addition of a short-wave channel, and a second short-wave channel was opened recently. In all these undertakings Hansford took his part, in personal work and in using his experience and knowledge to co-ordinate the efforts of others, difficulties disappearing as if by magic under his touch. He visited America and many European countries to forge and strengthen links in the rapidly lengthening chain of world communication, the completion of which had been made possible by the progress in long distance radio telephony. The recent experimental transmissions between London and Sydney, Australia, and the extension of this channel to New York, were the culminating successes of the group of engineers working under Hansford.

Glasgow University conferred the degree of Doctor of Science upon Hansford in 1926 for a thesis upon some aspects in the design of a high-power radio-telegraph transmitter, in which the scientific and practical considerations underlying his original work in connection with Rugby were set forth and described. The initial tests of Rugby were occupying him throughout the day and far into the night when this thesis was in preparation, and the time limit for its submission was within a fortnight of expiration when, without warning, demand was made upon him to examine the case for revision of Scales to be submitted to the Industrial Court by the Society of Post Office Engineers, and to appear as a witness before the Court. With his usual selflessness he put aside his own interests, and it is no secret that his trenchant criticism caused the case to be entirely remodelled at the eleventh hour, and that he tuned up his fellow witnesses in the inimitable Hansford way. The decision reached by the Court will be remembered as one of the rare cases adjudicated upon in which im-

Richard Vernon Hansford

The face of Death is toward the Sun of Life,
His shadow darkens earth: his truer name - -
Is "Onward," no discordance in the roll - - - -
And march of that Eternal Harmony - - - -
Whereto the worlds beat time, tho' faintly heard,
Until the great Hereafter. - - - - - - - - -

Tennyson



proved scales were granted. Hansford returned to his thesis with three or four days in hand and sufficient work outstanding upon it to occupy most men three times that period. Happily the task was accomplished.

The Institution of Electrical Engineers in 1927 awarded its Wireless Premium of £20 to Messrs. Hansford and Faulkner for a joint paper on " Notes on the design details of a Radio Transmitter using Thermionic Valves."

Hansford was appointed Secretary to the Institution of Post Office Electrical Engineers in 1923, and he retained the office until his death. Probably only members who have served on the Council of that body will appreciate fully the value of the services he rendered. The work of the Council was invariably carried on with orderliness and celerity, due largely to the series of Council Papers, which he issued in addition to the Agenda and which placed every member in possession of the essential facts and past history of matters to be discussed. On principle, as Secretary, he rarely intervened in debate except to clear up a doubtful point or to lead a straying discussion into the right path, but he was ever watchful of the interests of the Institution, and it is beyond question that he maintained and improved its position as a real force in the science and practice of communication engineering.

During the past two years Hansford served on the Comité Consultatif International des Communications Telephoniques and he was rapporteur of the Fifth Commission of the Committee. He attended conferences at Como, and Berlin and also the recent conference of the C.C.I. Radioelectrique at the Hague. His value in the deliberations of these international bodies was fully recognised, and the news of his decease brought expressions of sorrow and regret from delegates of many of the countries represented. He was examiner in the subject of Magnetism and Electricity for the examinations conducted by the City and Guilds of London Institute, and he served on an advisory committee to consider the curricula and syllabuses for the subjects of telegraphy, telephony and radio communication. He was also a member of the " Thermionics " sub-committee of the Radio Research Board and of the committee of the Wireless Section of the Institution of Electrical Engineers.

In Hansford's personality were combined high personal qualities, an amazing capacity for work, natural ability of exceptional order and the strength of character to utilise these attributes to the fullest extent. He had only one standard of quality, the highest, and he would not accept mediocrity of performance either from himself or from those who worked under him. On the other hand he was a most patient teacher and leader, and his criticisms were always concluded with a laugh and a jocular remark which removed sting without impairing effect. He knew how to direct and employ staff without imposing unnecessary restrictions on their efforts. He asked for no more than he was willing to give himself, and his subordinates adored him accordingly. He was incapable of idleness; with every minute utilised to the fullest extent his working day was double the length of that of most men. He was impatient only of personal illness, and his impatience arose not from the suffering involved but from its interference with his normal routine. Not even illness could, however, impair the cheerfulness which seemed ingrained in his disposition, and at the first sign of convalescence he would send out an urgent appeal for work. And yet with all his numerous activities Hansford never gave the impression that he was a slave to work : he was indeed always its master. If there were times when his friends feared for his health, and such fears were expressed, he would laugh them aside, and a day or two later he would appear brighter and more energetic than ever.

In everything that makes for pleasant social intercourse Hansford was richly endowed. His keen sense of humour, natural wit, powers of repartee and love of fun made him a central figure in any gathering in which he participated, whether a fireside talk, a children's party, a staff dinner or an informal function of a learned institution. His letters written in perfect idiomatic English and combining sound common-sense with original humour were a delight to their recipients. His laugh and the whimsicalities of expression which he was fond of adopting were infectious to a degree, and those who knew him intimately were often amused to find Hansfordian expressions on their lips or appearing in unexpected quarters. His humour, never used to hurt, was sparkling or subtle as the occasion demanded. His loyalty was unquestioned and unquestionable, and in return he obtained loyalty without stint from everybody with whom he came in contact. His friendship was indeed a thing to be coveted.

Hansford has left only pleasant memories behind him. Regret at his loss cannot be expressed in words. The gathering at his interment, representative of two continents and many countries, was indicative of his place in the hearts of those with whom he came in contact. He went when at the zenith of his powers, and when a brilliant past seemed to have assured a still more brilliant future, but we, who knew him, loved him and worked with him, will treasure his memory for the innate manliness of his character, for his sincere friendship and his inability to say or do anything inconsistent with our conception of the best type of gentleman. Our heartfelt sympathy will be extended to his sorrowing wife and mother, his two little sons and the other members of his family. Their burden is indeed heavy.

C.J.M.

FRANK WILLIAM DAVEY.

Frank W. Davey.

The many friends and colleagues of Mr. F. W. Davey will be grieved to learn that, as a result of continued ill-health, he has been obliged to retire from the Service at the age of 52. The Engineering Department is the poorer because of the enforced withdrawal of a brilliant product of the telegraphist school of Post Office Engineer; one of that dwindling band of pioneers in a rapidly developing profession.

Mr. Davey commenced his career as a telegraphist in 1892, serving for 3 years in the Inland and 8 years in the Foreign Sections of the Central Telegraph Office. In 1903 he was promoted to the class of Relay Clerk at Lowestoft and after 6 years' experience in this capacity he was advanced to the rank of Second Class Engineer on the Headquarters staff. In 1911 he was made an Assistant Engineer and promoted in 1924 to the rank of Executive Engineer.

Most of Mr. Davey's service at Headquarters has been devoted to specialised duties in telegraphy and wireless. In the development of radio, he has been responsible for much original work and this is exemplified by the following brief references to his professional career. When the wireless coast stations were transferred from the Marconi Company to the Post Office in 1909, Mr. Davey was responsible for the reconditioning and maintenance of the system and, under his direction, the first spark disc discharge set was installed at Fishguard. Later he was responsible for radio installations at the Valencia and Stonehaven stations, the latter being the first fast speed wireless telegraphy station erected for the Post Office. During the war Mr. Davey was responsible for the organisation and administration of the Army Wireless School at Farnborough, where large numbers of Royal Air Force personnel were trained under his direction. He was also retained during the war period as an expert witness in wireless prosecutions under the Defence of the Realm Act.

As an Executive Engineer in the Radio Section at Headquarters Mr. Davey had charge of construction and maintenance work connected with coast stations.

He represented the Engineer-in-Chief on several important committees dealing with radio work. He was a member of the Inter-Departmental Committee on Direction Finding, which led to the equipment of Post Office coast stations with direction finding equipment. Davey also acted as technical adviser to Trinity House in connection with the equipment of light ships and shore stations with wireless telephony.

He was a member of the Radio Research Board's sub-committee dealing with direction finding; a member of the committee appointed by the Board of Trade to deal with the provision of rotating beacon stations for safety of life at sea; also on the Wireless Section committee of the Institution of Electrical Engineers.

Mr. Davey has contributed papers and articles to the technical press, dealing with the theory of radio telegraphy and telephony and, in this connection, it is interesting to note that in 1922 he read a paper on the development of thermionic valves for wireless purposes in which he foreshadowed the opening up of telephonic communication with America.

It is true to say of Frank Davey that his unassuming modest nature shrinks from any sort of publicity. His wide reading makes him an excellent companion and his cheerful outlook on life will always remain a cherished possession to those who are privileged to be numbered among his friends. Now that there is less need for the study of matters scientific and technical, he will be enabled in his quiet country home in Essex to enjoy more fully than heretofore his abiding interest in literature.

A large number of his friends have combined to present Mr. Davey with a silver tea service, and an accompanying album containing the names of those who hold him in affectionate regard. This brief notice may fittingly close on a note of complete endorsement of the inscription in the album.

"To

FRANK WILLIAM DAVEY.

We, your colleagues in the General Post Office, desire your acceptance of the accompanying silver tea service as a token of our esteem and regard and we wish to express our deep sense of the loss we have sustained in your retirement.

We desire to place on record our high appreciation of your ready helpfulness and unfailing courtesy. We wish you many years of enjoyment of health and leisure and trust that many happy recollections of your 37 years' service may remain with you, as they do with us."

A.O.G.

* * * * * * *

In 1913, when I returned to Hearquarters to take up wireless work, I found the expert knowledge and the loyal support of my old friend F. W. Davey of immense value during what might otherwise have been a difficult time. He was always a progressive, bold and enthusiastic worker and I should like to take this opportunity of expressing my indebtedness to, and affection for him. It is a great regret to know that he has to retire, but I trust that, relieved of his arduous labours, he will be spared many years to enjoy a peaceful and happy life.

E. H. SHAUGHNESSY.

LONDON ENGINEERING DISTRICT NOTES.

TELEPHONE EXCHANGE PROGRESS.

New Automatic Exchanges.—The following exchanges have been opened during the past three months:—

Exchange.	*No. of equipped lines.*	*Manufacturer.*
Hendon	4,200	A.T.M.
Hillside	2,350	A.T.M.
Ilford	3,000	Siemens

Automatic equipment is being installed in the following new buildings:—

Addiscombe.
Fairfield.
Amherst.
Macaulay.
Primrose.
Shepherds Bush.

New Manual Exchanges.—The following installations are well in hand:—Redhill; Theydon Bois.

Manual Exchange Extensions.—The following extensions of equipment have been completed:—

Sydenham	2,000 lines
Wembley	680 ,,
Hounslow	1,220 ,,
Grangewood	780 ,,
Albert Dock	900 ,,
Grosvenor	Extension of C.C.I. equipment.
Langham	
Abercorn	
Speedwell	

CONCENTRATION OF NIGHT TRAFFIC AT LONDON EXCHANGES.

A measure of concentration of traffic *via* Tandem Exchange during late evening and night hours has recently been introduced which marks an important change in the method of handling traffic during these periods.

At 8.0 p.m. all outgoing junction traffic from Exchanges in the London Telephone area beyond the five mile circle to other Exchanges in the automatic area will be routed *via* Tandem, with a few exceptions, whilst at 9.0 p.m. all outgoing traffic from Exchanges within the five mile circle to Exchanges situated between the five and ten mile circles will also be routed *via* Tandem. As a result the " B " positions, at local exchanges other than the C.C.I., Trunks and Toll positions, will be closed at the above hours.

At Exchanges within the five mile circle, arrangements have been made to modify the order wire breakjack equipment so as to provide for a tone to be connected on the order wire keys of all the closed routes during the night time. If a telephonist depresses the order wire key associated with a route which is not open for traffic, a tone will be heard which will indicate that the traffic for that Exchange is to be routed *via* Tandem. The circuit has been so designed that the tone is only applied to the order wire circuits during the time an order wire button is depressed. This is achieved by the provision of a relay which is energised only when the order wire key is depressed and which, when actuated, joins up the tone. The tone will not, of course, be associated with the order wire breakjack equipment during the day time and its connection for night traffic discrimination will be under the control of the Traffic Staff. The procedure necessary to bring the tone into use is to transfer dummy breakjack plugs (which normally are in position in the top order wire breakjacks associated with the routes to be closed down) from their normal position to the corresponding lower jacks.

The new method will not only allow some economy in staff to be effected, but will also improve the grade of service during the night as the incoming calls will be dealt with at one point instead of being spread over a large switchboard.

PRIVATE BRANCH EXCHANGES.

In many of the great business houses of London there are telephone installations which are comparable with those of a small town. One has recently been provided for the Midland Bank in Poultry of which the details are as follows:—

7 100-line units.
35 first selectors.
7 second selectors.
63 final selectors.
8 manual boards.

Two 400 A.H. 50 volt batteries are fitted and also one 10 cell counter E.M.F. battery.

The capacity of the installation is 900 lines. At present there are working—

71 Exchange lines.
306 External extensions.
250 Internal extensions.
6 Auto tie lines.

FIVE POWER CONFERENCE.

Preparations for the Five Power Conference to be held in London early in 1930 are now in hand and although precise details of the Telegraphic and Telephonic requirements have not been fully developed it is probable that the Engineering Department will be concerned with a large amount of work at St. James' Palace. Requests have already been received for a suite of 50 call office cabinets and a large P.B.X. Provision for between 60 and 70 Exchange lines is being made. The number of extensions likely to be required is not yet known, but is sure to be large.

TELEGRAPHS.

On the 29th September the two Imperial Cables to Halifax, Nova Scotia, and the four Beam telegraph services to Australia, Canada, India and South Africa, which had been so successfully developed by the P.O., together with the associated apparatus, were regretfully handed over to Imperial and International Communications Ltd. The transfer was carried through without the slightest hitch, and without interruption of service.

The equipment of telegraph circuits in the C.T.O. with teleprinter apparatus is still proceeding and 26 sets have been brought into service during the past six months.

TELEPHONE CABINETS.

A suite of handsome oak telephone cabinets has been built in the District Workshops and installed in the headquarters of the London Fruit Exchange Brokers' Association at Spitalfields.

Suites of suitable Cabinets have also been provided at Paddington and Piccadilly railway stations.

RETIREMENT OF MR. J. COWIE.

Mr. Cowie entered the Post Office Engineering Department as a junior clerk in 1899. At that time he was taking a keen interest in technical matters and it was not, therefore, surprising that in 1902, when the Department was seeking suitable officers for employment upon the initial work in connection with the telephoning of London, Mr. Cowie was one of those selected. He was engaged upon this work as a Sub-Engineer for five years and was then transferred to Brighton where he acted as Assistant Engineer until 1924. During this period he became so thoroughly identified with the Section that it seemed difficult to think of Brighton without Cowie. Warm tributes were paid in the local press when in 1924 he left Brighton to take up the position of Executive Engineer at Manchester, and there is no doubt that the Department gained by the respect in which he was held by the officials of local authorities.

JAMES COWIE.

During the Great War Mr. Cowie was on loan for some time to the War Department for the training of Army Signallers. When he returned to the Post Office he received letters from the Major-General and Brigadier-General thanking him for his " most excellent work." In one of the letters reference was made to his " winning personality "—a phrase which all his civilian colleagues would apply to him.

Mr. Cowie was transferred to London in 1927 as Executive Engineer in charge of one of the most important sections at a time when automatic working on a large scale was being introduced.

He was first in charge of the internal portion of the work with all its new problems, and then was transferred to the external work. To each class of work he applied himself with his customary thoroughness and has left a mark on the Section which will endure.

He was interested in everything that affected the welfare of the Department and the Staff. He gave many courses of technical lectures and took a keen interest in the I.P.O.E.E., which he served as a member of the Council for a number of years and as Chairman of Sub-Committees.

The official farewell was paid on 28th November when, on behalf of his numerous well-wishers, Mr. Gomersall made a presentation and referred to the manner in which Mr. Cowie had won the esteem and affection of all those who had the privilege of being associated with him. Tributes were also paid by officers representing the various grades of engineering and clerical staff, and there was not the slightest doubt about the universality of the regret with which the farewell was said. Mr. Cowie has retired in excellent health and has returned to live at Brighton, where, it is hoped, he will spend a happy period of retirement with plenty of occupation to keep his active mind and body employed.

J.G.H.

PROVINCIAL DISTRICT NOTES.

DAMAGE TO A DUCT ROUTE BY LIGHTNING.

It is by no means an unusual event for underground cables to be damaged by lightning, and the very full protection now given by the usual protective equipment is a tacit acknowledgment of the existence of this danger. It is, however, most unusual, if not unique, for underground ducts—as distinct from cables—to be damaged by lightning; hence, considerable interest attaches to a case of this nature which happened near Ripon during a storm early last July.

The locality of the damage was Leeming Lane, near Ripon, Yorks, the exact spot being indicated by the standing figure in photograph No. 1. The duct line comprises a 3-way multiple duct, one way carrying the Leeds-Edinburgh Cable, the other two being spare.

In the early hours of Sunday morning, July 7th, 1929, a thunderstorm was in progress in this locality, and a near-by house, known as Theakstone Grange, was struck by lightning, which dislodged a few of the slates and damaged a chimney. This aroused the tenant and whilst looking out on the storm, he saw a lightning flash strike the ash tree (photo No. 1) travel down the trunk and to about half-way across the grass margin where it disappeared into the ground.

Being interested to know what had happened, he took an early opportunity of visiting the spot, and found a hole in the ground, somewhat re-

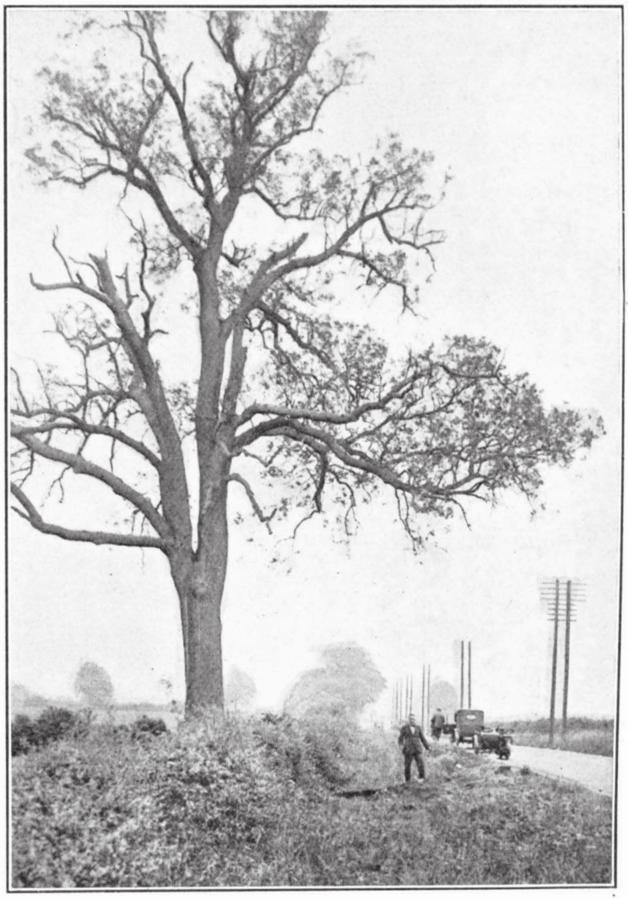


Fig. 1.—Showing trace of Discharge down Trunk.

sembling a rabbit hole. Evidently being aware of the existence of our cable, he reported this to the lineman, who, on arrival, carefully uncovered the ducts. It was found that three successive ducts had been damaged, the upperway in two of them having been shattered, and in the third, severely cracked around the socket. The lower ways in all cases were very badly cracked. The photographs clearly show the damage.

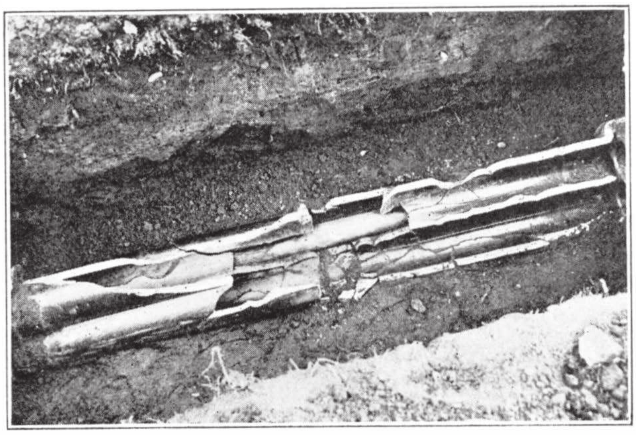


FIG. 2.—DAMAGE TO DUCTS.

Critical examination of the cable failed to bring to light the slightest sign of damage. A " close up " of the cable shows a slight marking found on the surface of the lead, but no sign of penetraton was seen anywhere. No trouble was noticed on the circuits, and the usual monthly test showed the cable was up to standard, so far as insulation was concerned.

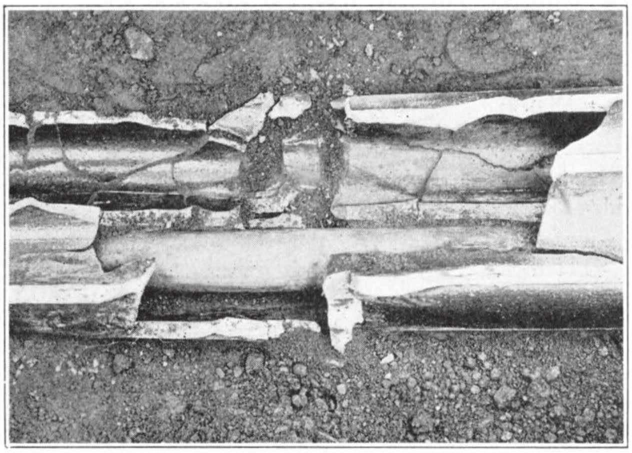


FIG. 3.—CENTRE PORTION OF DUCT SHOWN IN FIG. 2.

It is interesting to note that while no damage was done to the tree, the track of the flash can be seen down the trunk, and appears in the photograph as a white line down the extreme left-hand side.

It seems somewhat remarkable that the lightning should have turned aside from the tree at practically a right angle and travelled a few yards to reach our cable. Perhaps the tree was not efficiently earthed?

The behaviour of the tenant of Theakstone Grange deserves a few words. The man who can take precise and accurate meteorological observations, leading to the location of a " fault " on our plant, at a time when his roof slates and chimneys are flying about his ears, must surely command our respectful admiration.

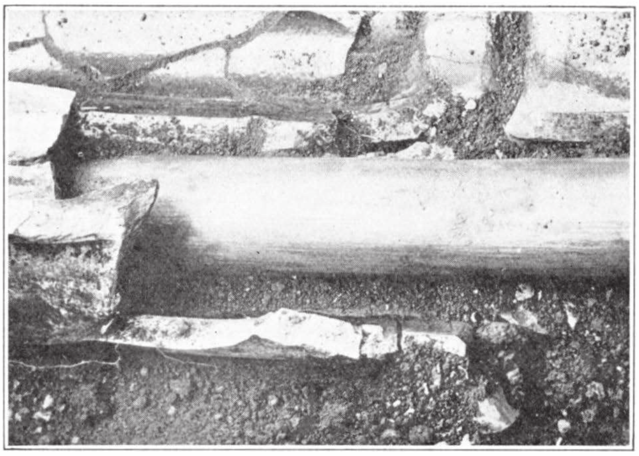


FIG. 4.—CABLE INTACT.

THOS. F. BARLOW.

A LANDMARK GONE.

Until recently the Department had two lattice masts, 120 ft. high, carrying main Trunks and Telegraphs alongside the toll bridge over the River Ouse at Selby, and for more than 30 years they were a conspicuous landmark. Owing to the withdrawal of wayleave

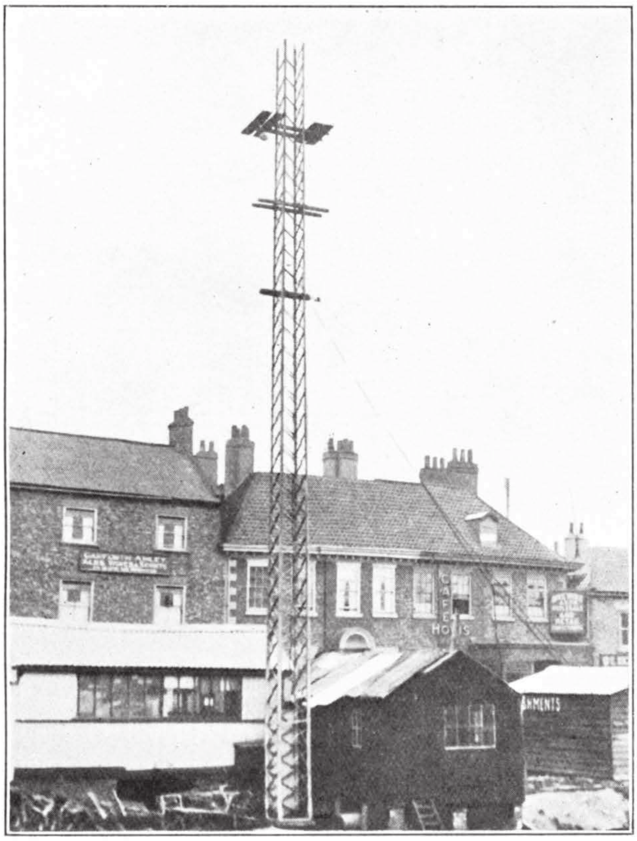


FIG. 1.—STAGING AND OXYACETELYENE APPARATUS.

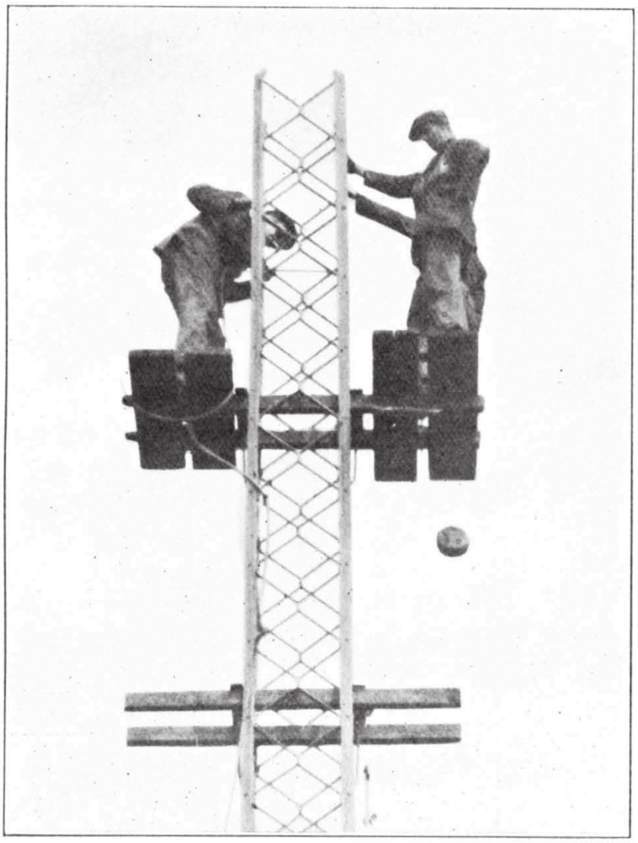


FIG. 2.—BURNING IN PROCESS.

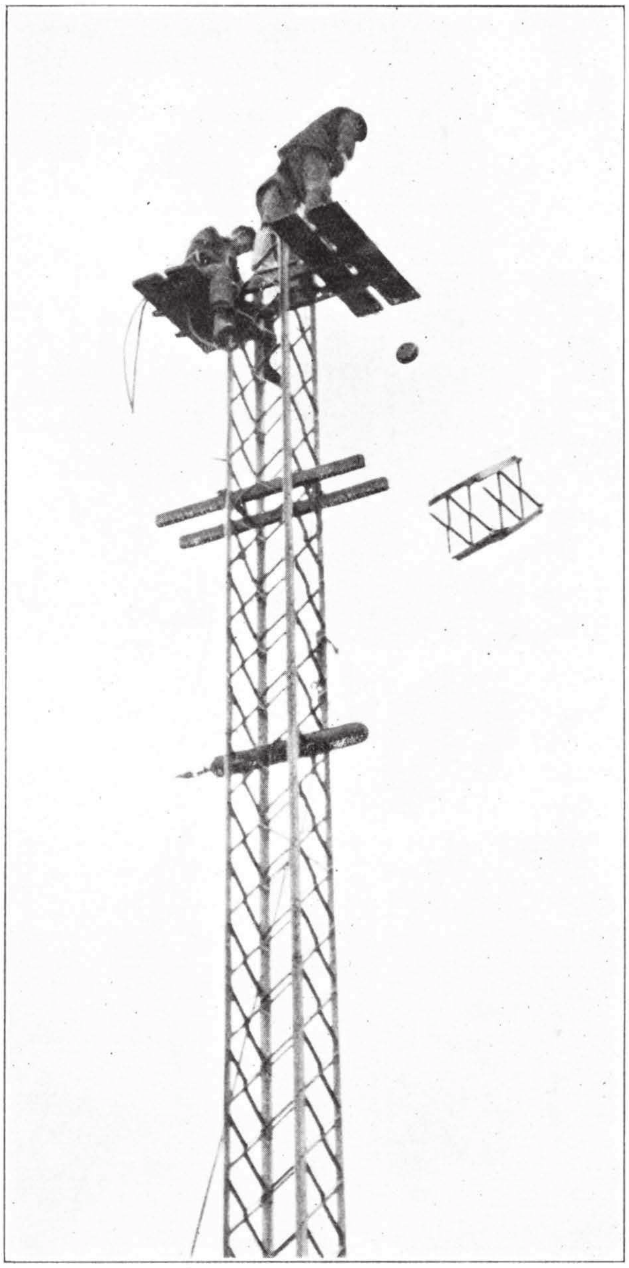


FIG. 3.—SECTIONS CUT AWAY AND ALLOWED TO DROP.

and the impossibility of finding alternative sites, the masts have been demolished, the circuits being diverted to a under-water cable.

The demolition of the masts was carried out by a steeplejack firm. At the commencement of the work the contractor used hack-saws, but later oxyacetylene gas was resorted to. Want of space prevented the masts being felled intact. The accompanying photographs taken by Mr. F. Vear, one of the York Inspectors, will be of interest.

W.P.

NEW CABLE ACROSS RIVER OUSE AT SELBY.

The demolition and removal of the 120 ft. masts on the north side of the toll bridge at Selby, referred to in the foregoing article, necessitated the laying of a cable across the river Ouse at that point.

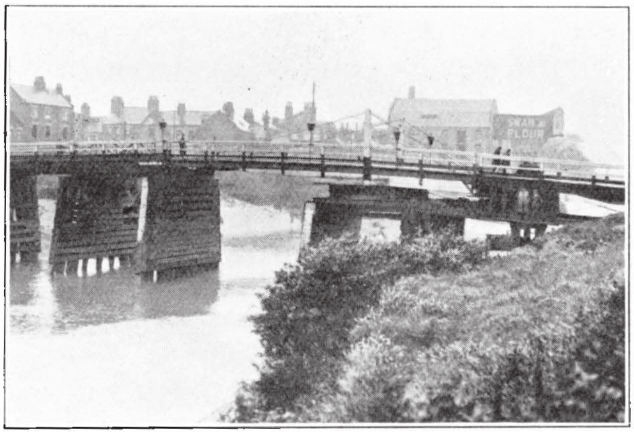


Fig. 1.—Toll Bridge, Selby.

The Leeds-Hull No. 1 cable and a local cable being *in situ* on the east side of the Bridge, the west side was chosen for the new cable. In addition to the trunks and telegraphs, provision was made for local circuits and a double-armoured cable containing 7 pr/70 + 46 pr/20 + 102 pr/10 conductors was supplied. The lay-

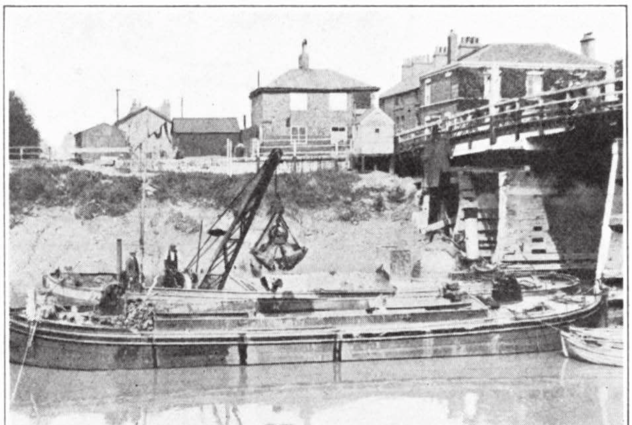


Fig. 2.—Dredger cutting Cable Trench.

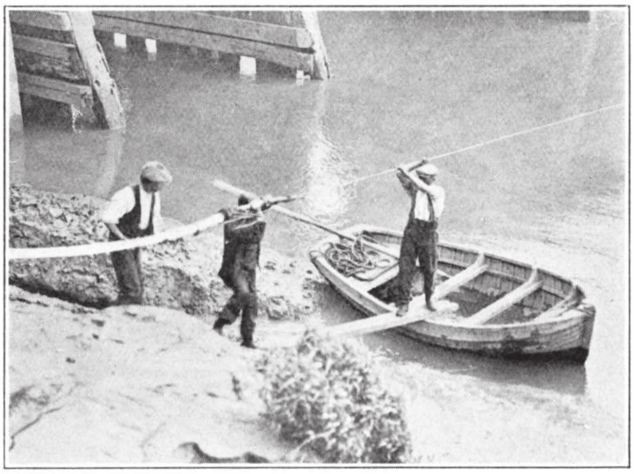


Fig. 3.—Carrying Cable to boat.

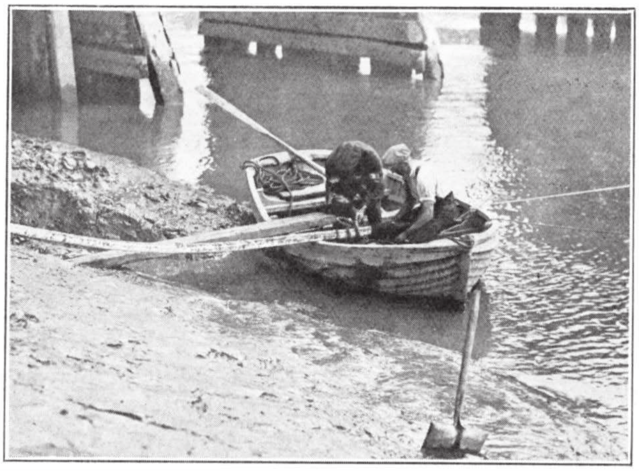


Fig. 4.—Lashing Cable to boat.

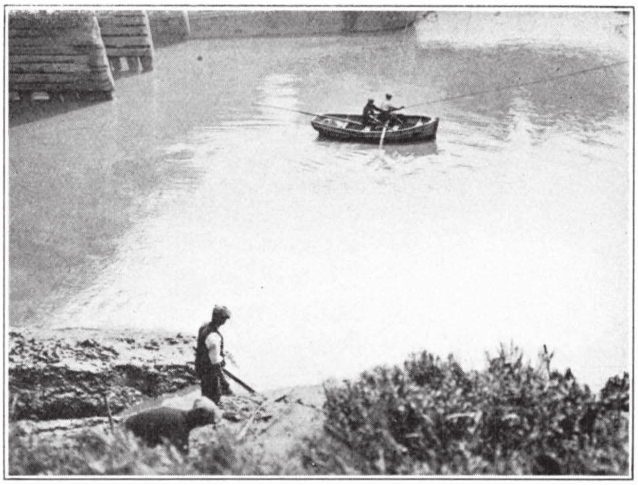


Fig. 5.—Conveying Cable across river.

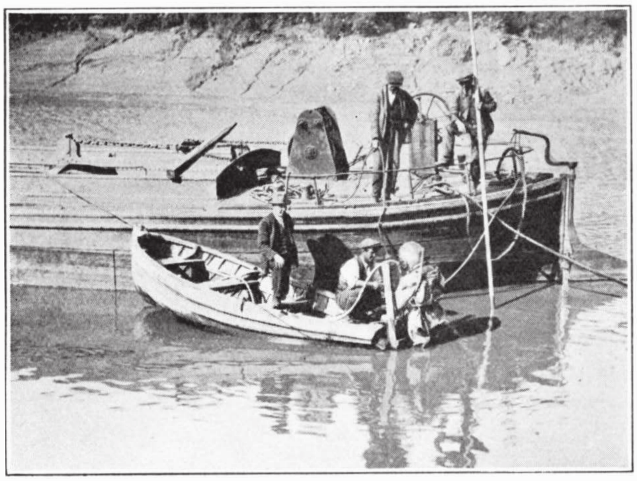


FIG. 6.—DIVER PREPARING TO DESCEND.

ing of the cable was let to a contractor and the specification provided for a trench 4′ deep in the hard bed of the river. A grab was used for excavating the trench and the cable was hauled across from north to south, the hauling tackle being on a barge on the south side. Sighting posts were erected on each side of the river as a guide for trenching and cable-laying. A diver verified that the cable was in the trench, which was then filled up with cliff stone. Photographs depicting the various stages of the work are shown.

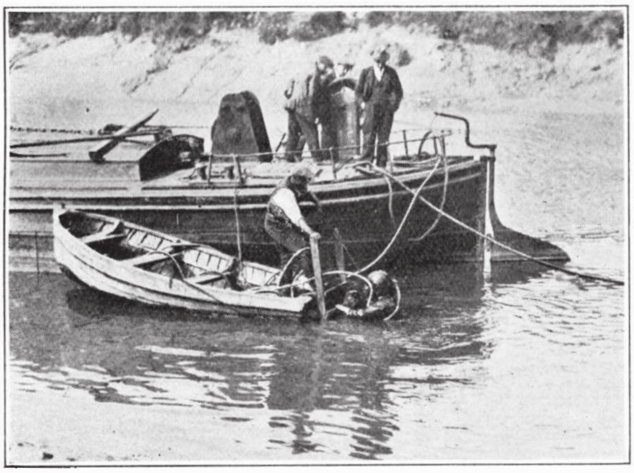


FIG. 7.—DIVER COMING TO SURFACE.

W.P.

SCHNEIDER TROPHY RACE.

The Special Telegraph and Telephone Arrangements for the Schneider Trophy Race, which took place over Spithead and the Solent in September last, were somewhat unusual. Ryde Pierhead, on the Isle of Wight, was the starting point and also the finishing point of the race. The competing planes were housed at Calshot, an isolated spit on the mainland dividing the Solent from Southampton Water.

It was decided on the 7th July by the Secretary to open two temporary Post Offices with telegraph and telephone facilities—one at Calshot and one at Ryde Pierhead. At Calshot the circuits required were 2 TSX-Calshot (with Repeaters at Southampton) and 6 Calshot-Southampton circuits, 6 additional TSX-SO circuits and 4 TS-Calshot teleprinter circuits. As it was impracticable to add further arms to the Trunk route to Southampton, it was decided to erect 176 miles of 40-lb. cadmium copper wire on eight arm-extension brackets per pole, to erect one mile of aerial cable and to draw underground cable into existing duct and concrete runways at the Aerodrome, where a room was allotted for the Post Office.

This work, together with the erection of eight Silence Cabinets and the Control Switchboard, was completed in three weeks. Two of the teleprinter circuits were superposed on two of the Southampton - Calshot Trunk circuits with smoothing devices, and two by cutting into a Southampton-Isle of Wight Trunk.

At Ryde Pierhead a room was allotted in the Royal Thames Yacht Club for the Post Office and Telegraphs (which consisted of four Wheatstone circuits and one D.C. circuit). The telephones, however, had to be placed in Silence Cabinets erected on a flat roof over the Pier Tramway Depot adjacent to the Post Office. Seventeen Cabinets in all were erected, protected against weather by tarpaulins and awnings, and fitted with electric light, as the circuits were in use up to midnight. The following circuits were provided:—

9 Pierhead-Ryde Ex. Telephone circuits.
1 ,, ,, ,, C.O. Attendants circuit.
7 Pierhead-TS private wires for newspapers and Cable Companies.

3 Pierhead-TSX B.B.C. circuits.
2 Private wires for the Royal Aero Club and the Southern Railway Co.
6 Additional TSX-Ryde Ex. circuits (repeatered at Portsmouth).

Two cables were run along the pier, which is half a mile long, and aerial cable over the Esplanade Railway Station, thence by underground to Ryde Exchange. As the Department had only 28 pair submarine outlets to Ryde from Southsea, permission was given by the Admiralty to use a 10 pr. G.P. cable and the ends were linked up with the P.O. Underground by drawing in $\frac{3}{4}$ mile of 15 pr. cable at Southsea.

The B.B.C. Hut was erected on a flat roof near the Timing Hut at the foot of the dome of the Pier Pavilion.

The arrangements were successfully carried out. Italian calls to Rome and Milan were of daily occurrence and the Broadcast was particularly good.

Complimentary letters were received from the B.B.C., Royal Aero Club, Cable Companies and others.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

BOOTH-BAUDOT AWARD.

The Council wishes to call attention to the "Booth-Baudot Award" of £5 which is now offered annually for the best improvement in Telegraph, Telephone or Wireless Apparatus or Systems. The award for the year 1929 is governed by the following conditions:—

1. The Award will be restricted to employees of the British Post Office.
2. Applications for the Award should be made between 1st January and 31st March, 1930, and such applications should refer to improvements made, or suggested, during the twelve months ending 31st December, 1929.

   Attention is drawn to the fact that recipients of Awards *via* the Post Office Awards Scheme in respect to any improvement in telegraph, telephone or wireless apparatus or systems are eligible to apply for the Booth-Baudot Award in respect thereto.
3. The Award may be withheld at the discretion of the Council of the Institution of Post Office Electrical Engineers if, after full consideration of the applications received, the adjudicators appointed by the Council are of the opinion that no award is warranted.
4. Applications for the Award, accompanied by full details of the improvement, should be addressed to the Secretary, The Institution of Post Office Electrical Engineers, G.P.O. (Alder House), London, E.C.1.

H. L. Dunster,
for Secretary.

November, 1929.

LOCAL CENTRE NOTES.

LONDON CENTRE.

The Session was opened on Tuesday, 8th October, by Mr. E. S. Ritter, D.F.H., A.M.I.E.E., who read a paper entitled "Picture Telegraphy." The paper was illustrated by lantern slides and a number of very fine photographs. Mr. Ritter dealt fully with the development of the different systems and the hearty vote of thanks at the close was a tribute to Mr. Ritter's knowledge and lucid exposition of a subject not yet widely known.

Before calling upon Mr. Ritter, the Chairman, Mr. A. B. Hart, M.I.E.E., made sympathetic reference to the death of Dr. Hansford, the members standing as a mark of respect.

The second meeting was held on Tuesday, 12th

November, when Mr. A. Speight, A.M.I.E.E., read a paper entitled "The Development of Automatic Routiners in the British Post Office," the paper being illustrated by lantern slides. Mr. Speight dealt comprehensively with the different types of Routiner and ably replied to the ensuing discussion.

INFORMAL MEETINGS.

The first Informal Meeting was held on Tuesday, 22nd October, when Mr. F. H. Wise, the Vice-Chairman of the London Centre, gave an opening address entitled "Costs of Works; chiefly External." An interesting and spirited discussion was opened by Major Brown and only the operation of the time limit enabled the meeting to close at the usual time.

The second Informal Meeting was held on Tuesday, 26th November, when Major H. Y. Starkey read a paper entitled "Maintenance Efficiency, Exchange and Subscribers' Apparatus Plant." Some Notes on Maintenance Units, Standards and relative economic considerations. The paper was illustrated by a series of lantern slides that enabled the members to realise the amount of time and thought which had been spent in collecting and co-ordinating the information on which Economic Considerations are based. Capt. J. G. Lucas opened an interesting discussion and the view was expressed by subsequent speakers that some means should be found to circulate the statistics for the benefit of the staff.

VISIT.

A successful visit was made to The National Physical Laboratory on November 9th. The members were welcomed by the Director, Sir Thomas Petavel, and afterwards conducted over the Electrical Standards, Wireless, Electrotechnics, Aerodynamics and Tank Departments. The tour was interesting and instructive and tea in the Canteen brought a thoroughly enjoyable visit to a close.

T.H.

NORTH WALES CENTRE.

The Session was opened on 9th October, 1929, when the Chairman delivered his opening address. Mr. Weaver commenced with a reference to the diversity of interests in the occupation of a Post Office Engineer and illustrated this by extracts from the Engineer-in-Chief's Annual Report. Following this he pointed out the profuse supply of information afforded to the Staff of the Department on almost every aspect of their work and the various training courses and technical classes organised to help the Staff to become acquainted with their work. He suggested, however, an extension of these activities in the form of a course of instruction for potential engineers in Estimating, P.O. Commercial Accounts, etc. Subsequently, the Chairman referred to the tremendous figures representing capital plant expenditure and compared the telephone statistics of England with those of other countries. He referred also to the brighter industrial outlook and the improved standard of living with the consequent expansion of telephone facilities and the resultant increases of staff and positions. In conclusion he emphasised the undesirability of having no interests other than official duties and of being able to leave business worries behind at the conclusion of office hours.

The second meeting was held at Birmingham on the 14th November, 1929, when Mr. E. S. Ritter, D.F.H., M.I.E.E., of the Engineer-in-Chief's Office, read his paper on "Picture Telegraphy." At the outset Mr. Ritter explained the construction and working of the photo cell and selenium cell and demonstrated the effects of light projected on a photo electric cell. He then proceeded to the methods of transmitting and receiving, synchronisation, phasing, signalling and speaking, and, in the latter part of his paper, the principal types of apparatus now in use. After the reading of the paper an interval was allowed during which the audience examined the exhibition of photographs transmitted over various circuits, which Mr. Ritter had collected. The ensuing discussion brought forth a considerable number of questions and compliments on Mr. Ritter's interesting treatment of the subject.

NORTH MIDLAND DISTRICT.

A presentation, which took the form of a portable wireless set, was made on 30th September, 1929, to Mr. William Allan on his retirement from the Service as Acting Superintending Engineer of the North Midland District.

Mr. A. B. Gilbert, Superintending Engineer, presided over a gathering of over 70 members of the staff. Mr. Gilbert referred to his happy association with Mr. Allan in the early days of their service. The presentation was made by Mr. Arundel and reference was made by Messrs. Blower, Vyle (Clerical), Partridge, Kemp (Sectional Engineers) and Read (Inspector), to the friendship and esteem in which Mr. Allan was held throughout the District and to his unfailing courtesy in dealing with all ranks. Valedictory messages were received from Messrs. Bullock, Nichols, Lomas, Walker, Tissington and the Vice-Chairman of the District Whitley Committee.

SOUTH LANCASHIRE CENTRE.

The Session opened on Monday, 14th October, when the Chairman, Mr. W. J. Medlyn, gave his annual address under the title of "Progress and Development in the Post Office Engineering Department."

The address, which was greatly appreciated by the members and visitors present, gave an interesting outline of the various activities of the Engineering Department and the share which the South Lancashire District has taken in the work.

Several speakers subsequently expressed regret that this would be the last of a series of addresses given by Mr. Medlyn over ten consecutive years, and paid tribute to the excellent manner in which the task had been undertaken.

The second meeting of the Session was held on Monday, November 11th, when Mr. H. M. Turner read a paper on "Small Power Rectifiers."

This paper dealt very fully and clearly with a large number of different types of rectifying devices and aroused considerable interest and discussion.

NORTH WESTERN CENTRE.

SESSION 1929-30. LOCAL ORGANISATION.

Chairman—Mr. J. M. Shackleton, M.I.E.E.
Vice-Chairman—Mr. S. Upton, M.I.E.E.
Representing:—
  Executive Engineers—Mr. W. H. Lane.
  Assistant Engineers—Mr. A. S. Carr, B.A. (Cantab.), A.M.I.E.E.
  Clerical Staff—Mr. W. G. Morris.
  Chief Inspectors—Mr. R. A. G. Chambers.
  Inspectors—Mr. W. Bocock, A.M.I.E.E.
  Draughtsmen—Mr. H. F. Perry.
Librarian—Mr. H. Howarth.
Secretary—Mr. D. Barratt.

The opening meeting of the Session was held in St. George's Hall, Preston, on the 14th October, 1929, when a paper entitled "Telephone Transmission," being a description of the standard arrangements for giving effective transmission to telephone subscrbers, was read by Mr. W. H. Lane.

Mr. Lane opened his paper with a reference to the traffic arrangements for the putting through of telephone calls, the functions of Zone, Group and Exchange Areas, and the standards required for each. He then proceeded to deal with the Engineering problem of how best to obtain ideal conditions and explained the subscribers' circuit requirements at length, touching upon the application of the Standard Cable Equivalents and the composition of the various circuits. The paper was illustrated by specially prepared diagrams and was followed by a discussion.

On the 12th November, 1929, Mr. A. Morris, A.R.C.Sc., M.I.E.E., of the Research Section, Engineer-in-Chief's Office, visited Preston and read a paper entitled "Telephone Cable Circuit Interference."

Mr. Morris opened with a review of the main causes of disturbance in telephone cable circuits. The subject was then dealt with under the following headings:—

Telephone Cable Circuit Development, Cable Balancing for interference immunity purposes, Unbalances in telephone cable circuits, Cross Talk, Noises, Interference Characteristics, Prediction of cross-talk results, Control of overall cross-talk and noise in telephone circuits, and concluded with a description of modern improvements in the design and construction of telephone cable circuits from the interference immunity point of view.

The paper was illustrated by lantern slides, and it was evident from the subsequent discussion that the lecture had aroused considerable interest. A number of queries were raised by the various speakers and Mr. Morris replied to them.

The third meeting of the Session was held at Preston on the 9th December, 1929, when a paper entitled "Some Considerations relating to the Clerical Organisation of the Engineering Department" was read by Mr. A. S. Renshaw, of the Engineer-in-Chief's Office. The following is a synopsis of the paper:—

Organisation, Standardisation, Co-ordination, Inspections, Devolution versus Decentralisation, Recruitment of Staff, Review of special aspects of work involved, Current and future developments, Conclusion.

The lecture was exceedingly interesting and informative and provoked an animated discussion.

D.B.

SCOTLAND WEST CENTRE.

The first meeting of the Session took place on 7th October, the proceedings being of an informal character. After the routine business had been disposed of, a vote of welcome to the new Vice-Chairman of the Centre, Major Cameron, centred around the construction of medium open lines in country districts, and the consideration of standardised methods with a view to reduction of costs. All aspects of the day's work of a gang employed on such work were reviewed and a large number of speakers contributed their ideas on the various points raised.

Other subjects for discussion were on the agenda, but time did not permit of these being brought forward. This was the first "Informal" meeting held in the centre, but in view of its unqualified success arrangements will be made for others from time to time.

H.C.M.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

Officers of Colonial and Foreign Telegraph Administrations who are engaged in Electrical Engineering Works may be admitted as Colonial and Foreign Corresponding Members respectively, after application.

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Forms of application for Colonial and Foreign Membership can be obtained on application to

The Secretary,
Institution of P.O.E. Engineers,
G.P.O. (Alder House), E.C.1.

or the undermentioned gentlemen who have kindly agreed to act as representatives of the Institution in their respective countries:—

R. Badenach, Esq., B.Sc. (Melb.),
Chief Engineer's Office,
Postmaster-General's Department,
Treasury Gardens,
Melbourne, C2,
Australia.

H. C. Brent, Esq.,
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N. N. Banerjee, Esq., A.M.I.E.E. (Ind.),
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Calcutta West Division,
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A. T. Kingston, Esq., M.B.E., A.M.I.E.E.,
Office of the Chief Engineer,
Telegraphs & Telephones,
C.T.O.,
Colombo,
Ceylon.

A. J. Kellaway, Esq.,
Department of Posts and Telegraphs,
P.O. Box 366,
Pietermaritzburg,
South Africa

CENTRAL LIBRARY.

The following books have been added to the Central Library. Applications for the loan of same should be addressed to the Librarian, Institution of P.O. Electrical Engineers, Alder House, E.C.1.

LIST VI.

No.	*Title.*	*Author.*
886	Naval Electrical Manual (1928) ...	
887	Whittakers Electrical Pocket Book	R. E. Neale.
888	Television	A Dinsdale.
889	Alkaline Accumulators	J. T. Crennell and F. M. Lea.
890	Conduction of Electricity through Gases	Sir J. J. Thomson & J. P. Thompson.
891A	Essays Prize Competition, 1928-29:—	
	(1) Modern Theories of Electricity and Magnetism	G. Franklin.
	(2) Telephone Transmission Measurement on Repeater Circuits	F. E. Wright.
	(3) Maintenance of Subscribers' Apparatus in Automatic Areas	C. H. Hartwell.
	(4) Radio Methods in Telegraphy and Telephony	N. V. Knight.
	(5) General Analysis of Faults in a Director Automatic Exchange	W. H. Owens.
891B	(6) Photo-Copying and the P.O. Engineering Department	R. E. Gray.
	(7) The Preparation of Development Schemes	S. B. Iles.
	(8) Landing the Shore End of a Submarine Cable	W. E. Everson.
	(9) The Study of the Oak ...	H. Chapman.
892	Imperial Telegraphic Communication	C. Bright.
893	Electricity and the Electric Telegraph	J. B. Prescott.
894	Telegraphy and Telephony, including Wireless	E. Mallett.
895	ABC of Television	R. F. Yates.
896	Speech and Hearing	H. Fletcher.
897	Estimating	T. H. Hargrave.
898	Engineering Economics	T. H. Burnham.
899	Practical Geometry and Engineering Graphics	W. Abbott.
900	Differential Equations, Elementary Treatise	H. T. H. Piaggio.
901	A.T.M. Telegraph Engineers' Handbook	
902	Private Auto Branch Exchanges...	R. T. Dennison.

BOOK REVIEWS.

"Telegraphy and Telephony," including Wireless communication. An introductory text-book to the science and art of the electrical communication of intelligence. E. Mallett, D.Sc. (Eng.), London. Chapman & Hall, Ltd. 21/-.

The author of this book is an old friend of many Post Office Engineers. He has had the advantage of practical experience, both in telephone engineering and in teaching engineering subjects. Although he has been engaged now for a good many years on educational practice the contents of the book show that he has kept in close touch with practical engineering work.

The book is intended to fill the gap between text-books dealing with elementary electricity and magnetism and their application to telegraphy and telephony and those more advanced treatises on the various specialised branches such as telephonic transmission or automatic telephony. It deals with the application of the general principles of electricity and magnetism to all branches of communication engineering.

The general method followed in dealing with any given section of telegraphy or telephony is to give a short description of the apparatus or system under consideration, followed by the theoretical considerations involved in its design and action.

The book is divided into three main parts—Line Telegraphy, Line Telephony and Wireless Telegraphy and Telephony. The part dealing with Line Telegraphy includes apparatus, systems and transmission theory over short and long lines. Transient effects are dealt with at some length in this section.

The subject of Line Telephony is introduced by a consideration of the nature and theory of sound, followed by telephone instruments, line transmission, thermionic valves and exchange systems.

The part dealing with Wireless Telegraphy and Telephony includes the transmission of electromagnetic waves, the theory of high-frequency circuits and the generation and reception of high-frequency signals.

At the end of the book are appendices giving mathematical tables and proofs, etc., which could not be included in the text.

The range covered by the book is so wide that it has not been possible to do more than introduce many of the subjects considered. For this reason an extensive series of references is given at the end of each chapter, which enables the reader to pursue the subject further.

There is very little in the book which is open to criticism. It is considered, however, that the following points should receive attention in future editions. A considerable amount of space is devoted to the consideration of transients in telegraphy, but the question of transients in telephony is dealt with in a single paragraph in the chapter on valves, to which it does not appear to belong. In view of the fact that transient effects form the chief limiting factor to the distance over which telephone communication can be established they certainly deserve more consideration. In this connection the statement (on page 177) that "what happens during the transient period . . . is only of minor if of any importance" may be said to belong to pre-repeater days.

In connection with repeaters, the importance of the repeater being of the same impedance as that of the line is not mentioned, and no mention is made of means for regulating the amplification. The method mentioned on page 240 of facilitating the balancing of duplex repeaters by shunting the line with a small condenser has been abandoned as it is liable to produce reflection effects.

No mention is made of "sub-audio" telegraphs, and very little of picture telegraphy, both of which offer excellent pegs on to which to hang mathematics. Perhaps also mention should be made of the telephonic speech standards set up in the United States and in Paris.

It will be seen that most of the above points concern omissions and it is perhaps scarcely fair to criticise a book covering such a wide field on such grounds. It is hoped that the next edition will expand itself into three volumes, which could be easily filled with the material available.

The book fulfils a long-felt want and can be thoroughly recommended to all interested in the technics of communication engineering.

"On the Lichtenberg Figures. Part III., The Positive Figures." By P. O. Pedersen. Copenhagen, Andr. Holst & Son. pp. 138, with 28 plates. Price Kr. 10.00.

The history of electricity provides numerous records of discoveries made, in some cases, when the science was in its infancy, which were regarded for generations merely as interesting phenomena and incapable of utilisation, but which have been applied to practical uses during the last few years.

No better example can be cited than the discovery by Lichtenberg in 1777 of the formation of the electrical dust figures which have been named after him.

Lichtenberg discovered that when a charged conductor was brought close to or made to touch the surface of a cake of resin a charge was left on the resin the distribution of which could be rendered visible by sprinkling the resin with fine dust sifted through muslin. The dust mixture usually consists of red lead and sulphur or vermillion and lycopodium powder. The particles rub one against another and against the muslin and become electrified, the sulphur negatively and the red lead positively. The dust particles are attracted by charges of opposite polarity on the cake of resin and as a result the positively electrified places appear yellow and the negatively electrified places red.

It was subsequently discovered that an ordinary photographic plate could be substituted for the cake of resin and that if developed after electrification similar figures appeared.

There is a marked difference between the shape and general appearance of figures produced by a positive charge and of those produced by a negative charge.

Of recent years photographic records of Lichtenberg figures have been used to study the surges on high tension lines, especially the kind of surges due to lightning. One piece of apparatus used for this purpose is called the Klydonograph. The figures have also been used for the measurement of very short intervals of time down to 10^{-10} seconds and even less.

The Lichtenberg figures have been the subject of exhaustive study by Dr. P. O. Pedersen, Principal and Professor of the Royal Technical College, Copenhagen.

The present volume published in the English language under the auspices of the Royal Danish Society of Science deals with the positive figures and is complementary to two earlier works published in 1919 and 1922 on the negative figures.

One of the most interesting features of the work is the excellent series of photographic reproductions of actual figures taken under various conditions.

As a result of his investigations the author has developed the theory that the spreaders which are such a characteristic feature of the positive figures owe their formation to protons which the strong field at the tip of the spreaders drives out with great velocity. The investigations described further indicate that protons play an important role not only in the formation of positive Lichtenberg figures, but that their importance in connection with spark formation is much greater than hitherto assumed.

The book is a most interesting and authoritative source of information on a subject which is becoming of increasing importance to those engineers and physicists whose work deals with the study of transient electrical phenomena.

"Radio Telegraphy and Telephony." By R. L. Duncan and C. E. Drew. New York, John Wiley & Sons Inc. (London, Chapman & Hall). pp. 950, price 37/6.

This book in a sub-title is claimed to be a complete text-book for students of radio communication. It covers a large range, but deals with the subject in a descriptive manner with a marked absence of mathematical treatment. As a result, the book is not a satisfactory text-book for students who desire to obtain anything more than a superficial knowledge of the subject.

A large portion of the work is taken up with descriptions of actual transmitting sets—more especially those manufactured by the Radio Corporation of America—together with operating instructions for such sets, and is the type of information usually supplied by manufacturers' descriptive pamphlets. This is probably the most interesting feature of the work, as it gives the radio engineer a fairly complete idea of current American practice in transmitter construction.

There are numerous errors in the book, even in elementary descriptions; for example, on page 511 various types of condensers are described and under the heading " Oil Type Condenser " we read " In this condenser sheets of glass or other insulating material are coated with tinfoil to a reasonable distance from the edges of the glass to prevent brush discharge. The plate and dielectric sections are then placed in a suitable tank containing insulating oil (oil free from all minerals). The pure oil is used for the dielectric material." Now this type of condenser is the well-known glass plate condenser used on many spark installations and the glass plates, not the oil, constitute the dielectric. The function of the oil is merely to prevent brush discharges and to facilitate cooling.

Another example of muddled expression occurs on page 523 under the heading Tuning: " The frequency of an a-c circuit composed of inductance and capacity should be so regulated that at the instant the voltage reaches its peak value the current flowing will have produced considerable energy in the form of magnetic field round the inductance." The foregoing is typical of the kind of explanation offered in this work: there is also much needless repetition.

" Radio Traffic Manual and Operating Regulations." By R. L. Duncan and C. E. Drew. New York, John Wiley & Sons Inc. (London, Chapman & Hall). pp. 187, price 10/-.

This book is intended as a guide book for operators. It consists of six chapters, the first of which deals with the Morse Code and the usual abbreviations. The greater portion of the book is contained in the second and third chapters, which consist respectively of the operating rules and regulations of the Radiomarine Corporation of America and the text of the Washington Convention. The fourth and fifth chapters give the text of two American Acts, the Radio Act of 1927 and the Ship Act of 1912. The final chapter consists of the Regulations covering the issue of operators' licenses in the United States.

There is nothing of an original character in the book and nothing which is not accessible to the public in other ways, except perhaps the operating rules, which of course only apply to the personnel of the particular operating company concerned. As a result the book is not likely to find a large public on this side of the Atlantic.

" Elements of Radio Communication." By John H. Morecroft. New York, John Wiley & Sons Inc. (London, Chapman & Hall). pp. 269, price 15/-.

The present work is intended as an introductory volume to the author's more advanced work " Principles of Radio Communication." The latter work, since its first publication, has been recognised as a thoroughly comprehensive and standard work on the subject, but it is rather too advanced for many students who require a sound elementary knowledge of the subject, but who have not the time to study the larger work.

The present work is not a collection of excerpts from the larger volume, but has been written entirely anew.

Practically no mathematical preparation more advanced than elementary algebra is required for complete mastery of the text.

The book is divided into seven chapters, commencing with the simple laws of the electric circuit and special laws of radio circuits. Chapters three and four deal respectively with general ideas or radio communication and the vacuum tube and its uses. Chapters five and six deal respectively with radio telegraphy and radio telephony, while the final chapter is on receiving sets.

The subject is dealt with in a very thorough manner, within the limits that the author has set. Where necessary to clarify any point numerical examples are given, worked out in full. In addition, at the end of the book are a number of problems grouped under chapter headings. The usefulness of the book to private students would have been increased if the solutions to these problems had been given.

The book contains 170 figures and is also furnished with an index. One of the good features of the book is that the curves used to demonstrate various laws, such as valve characteristics, reactances, etc., have in most cases been plotted from actual measured values.

Altogether this work appears to be a very satisfactory elementary text-book which can be recommended for class use.

"Private Automatic Branch Exchanges." R. T. A. Dennison. Sir Isaac Pitmans. 12/6.

This book is a useful addition to the series of works on Automatic Telephony.

The author's aim is to present a volume giving the essential details of the circuits incorporated in several systems of Automatic P.B.X.'s, provided for subscribers' use in connection with their internal and public exchange services in this country.

To that end the book meets a definite need for a comprehensive treatise devoted to P.A.B.X.'s, which, although secondary in importance to Public exchanges, are not a negligible part of the field covered by the telephone engineer. Approximately 27,000 telephones are working on the P.A.B.X.'s in this country at the present date.

The volume under review describes, in the fullest detail, the circuit operations involved in the following typical systems:—

The Relay Automatic Co.'s 24 and 32 volt system.
The Line Finder system of the Standard Telephones & Cables, Ltd.
The systems of Messrs. Siemens Bros., and
The Automatic Telephone Manufacturing Co., utilising Strowger type equipment.

An outstanding feature is the large number of diagrams and photographs excellently reproduced and clearly described in the letterpress. The large folded diagrams are arranged for ready reference outside the letterpress as required when reading the circuit descriptions, this being particularly useful to the student of such a book.

The subject matter has been well and carefully compiled, and although the majority of the diagrams are copies of official diagrams these have been dissected and portions inserted in the body of the letterpress in explanation of some difficult principle or circuit operation.

The book can be recommended to anyone desirous of obtaining a close detailed knowledge of P.A.B.X. circuits and to others who wish to improve their general acquaintance with the subject.

In future editions a dimensioned sketch of one or two typical P.A.B.X. floor plan lay-outs would be useful, as well as a little more data on actual current consumption, extension to extension calls, extension to manual board, extension to public exchange.

The author can be congratulated, as the book is particularly free from material errors, considering the large number of cross-references used in the diagrams and letterpress.

F.B.

"High Voltage Cables." By P. Dunsheath, O.B.E., M.A. (Cantab), B.Sc.Eng., F.Inst.P., M.I.E.E. 158 pp. Sir Isaac Pitman & Sons, Ltd. Price, 10/6.

Modern developments in the generation and transmission of electrical power at high pressures have rendered the design of cables a matter of great importance, necessitating a large amount of research into the characteristics of dielectrics, especially having regard to changes which may occur after cables are put into service.

This book, which is based on a course of lectures delivered by the author at University College, London, can be thoroughly recommended to any engineer or student interested in the subject. It is both informative and readable, while the illustrations dealing with experimental work are excellent.

The author, after first dealing with the manner in which the growth of underground transmission has affected the problem, discusses very fully the electrical properties of dielectrics, alone and in combination, showing how the presence of other dielectrics, water, gas, etc., affects the distribution of stress. Dielectric power factor and losses, and the various methods employed in measuring these are also dealt with, while the theories underlying the behaviour of the materials are discussed and well illustrated by experiments.

In the final chapters the author concentrates on the properties of impregnated paper cables and their different designs, leading to the use of single core cables for very high voltages. The adoption of these has led to further problems owing to the high sheath losses which may be introduced by the methods of laying adopted for the cables, and these and the use of oil filled cables to overcome the shifting of the dielectric in laying the cables or under the action of gravity are also considered.

References are given, at the end of each chapter, to important papers dealing with the subject, for those who wish to pursue the matter further.

J. McG.

" Loaded Submarine Telephone and Telegraph Cables." Messrs. Siemens Bros. & Co., Ltd., Woolwich.

The volume gives an account of the loaded submarine telephone and telegraph cables manufactured, and in most cases also laid, by the firm, one of the pioneers in this branch of the electrical industry. The opening chapter deals with loading in a general way, while successive chapters contain illustrated descriptions, supplemented by copious tabular matter, of coil-loaded and continuously-loaded telephone cables insulated with gutta-percha and paper respectively, and continuously-loaded gutta-percha insulated telegraph cables.

A brief mathematical treatise on telephonic and telegraphic transmission is given in an Appendix.

The book is sumptuously bound and forms a very worthy record of the valuable work carried out by this firm.

" Das Reichspost Zentralamt." A Commemoration Book. The Post Office Administration has issued a profusely illustrated and finely printed volume as a souvenir of the opening of the new P.O. central buildings in Berlin. The coloured frontispiece gives a fine view of the front administrative blocks, surrounded on two sides by outbuildings and stores, with railway sidings behind. The Administration is to be complimented not only on the accommodation provided, but on the enterprise which evolved such a fine memento of the occasion.

" Overhead Power Lines. Elementary Designs and Calculations." Capt W. Morecombe Chapman & Hall. 15/- net.

The aim of this book seems to be to assist the Engineer engaged in the construction of overhead power lines to prepare his designs so as to fulfil as far a possible within the limitations of the uncertainty which surrounds some of the Regulations of the Electricity Commissioners.

There is a short chapter on the electrical properties of transmission lines, but the greater part of the book is devoted to the problems of mechanical design. Detailed methods of proportioning the various components of overhead structures to satisfy the load conditions are given, and consideration is given to the most recently developed forms of compound wood poles. Considerable attention is devoted to the strength of pole foundations, a subject which is too often neglected.

Ferro-concrete poles are dismissed rather summarily, but this is perhaps natural in view of the small use which has been made of this type of pole in this country. It would, however, have been interesting to have seen the " spun " ferro-concrete pole treated, since apart from the fact that this type of pole cannot be made by the roadside, it appears to be the most promising design both from the point of view of cost and weight compared with wood poles.

The safety requirements of the Electricity Commissioners and of the Post Office are treated fully and reprints of the latest safety regulations are given as appendices.

H.C.

" Worked Examples in Electrical Technology." By F. Peasgood, A.M.I.E.E., and H. G. Boyland, A.M.I.E.E. Oxford University Press. 15/- net.

There has long been a need for a collection of worked examples in Electrical Technology and the authors, who are lecturers in Electrical Engineering at the Northampton Polytechnic Institute, London, are to be congratulated for the business-like manner in which they have treated their subject.

The book is divided into three parts which deal respectively with the Direct Current circuit, the Magnetic circuit and the Alternating Current circuit. The examples, of which there are 110 in all, are graded and have been carefully chosen. They are worked out in that minuteness of detail which delights the eye of an examiner and each part concludes with a number of questions, to which answers are given, on which the reader may try his skill.

This very useful addition to the ever-growing literature on Electrical Engineering should prove useful alike to engineers desirous of a "refresher" and to students entering for the B.Sc. (Eng.), A.M.I.E.E., or other examinations of a similar standard. The book is excellently printed on stout paper which should withstand the handling to which a book of reference is subject.

"Questions and Solutions in Magnetism and Electricity." Solutions by William J. White, A.M.I.E.E. Third Edition. Sir Isaac Pitman & Sons, Ltd. 5/- net.

The third edition of this useful book makes a welcome appearance. The solutions to the questions set at the examinations in Magnetism and Electricity held during the years 1922-29 by the City and Guilds of London Institute have been added. As a result the book contains nearly twice the number of pages as the previous edition, hence the increase in price.

The second edition was reviewed on p. 282, Vol. 14 of the Journal and the criticisms there made still obtain. In addition, there is a slip on p. 175 where the word "charges" should read "changes."

The book should continue supreme in its sphere of usefulness both to students and lecturers in this subject.

W.S.P.

CURRENT LITERATURE.

The Journal of the Institution of Electrical Engineers, Vol. 67, No. 393, September, 1929.

Direct Generation of Alternating Current at High Voltages. Hon. Sir Charles A. Parsons, O.M., K.C.B., F.R.S., Honorary Member, and J. Rosen, Member.

Recent Developments in Turbo-Generators. J. A. Kuyser, Member.

A Measurement of the Sound Pressures on an Obstacle. W. West, B.A., Associate Member. An investigation of the performance of a small condenser transmitter under different conditions of test. The accuracies of the methods of measurement are discussed.

A Precise Electrometer Method for Voltage-Transformer Testing. R. S. J. Spilsbury, B.Sc., Associate Member.

The Rotor Bearings of Electricity Meters. W. Lawson, Member.

Discussions on "The Construction of the 'Grid' Transmission System in Great Britain," "Practice and Progress in Combustion of Coal as applied to Steam Generation" and on the first two papers quoted above.

Vol. 67, No. 394, October, 1929.

The Testing of Porcelain Insulators. B. L. Goodlet, Associate Member. The paper discusses the technique of porcelain insulator testing, and includes the usual electrical and mechanical tests called for in the various national specifications and also special tests of more recent origin.

The Modern Use of Pulverised Fuel in Power Stations. R. A. Chattock, Past-President.

Some Technical Considerations concerning Power Factor in relation to Tariffs. E. W. Hill, Member.

Directions for the Study of Micanite. Report of the British Electrical and Allied Industries Research Association. Classification of material and Notes on Manufacture, Use and Characteristics. Methods of Test.

A Portable Electric Harmonic Analyser. R. Thornton Coe, M.A., M.Sc.Tech., Associate Member. Paper describes a perfection of the dynamometer method of harmonic analysis in which accuracy and speed of operation have been combined with portability. The method gives the harmonics correct to 1/20th of 1 per cent. of the fundamental and can also be used for the analysis of current waves and for finding the phase angle between harmonics of the same frequency in two different waves.

Vol. 67, No. 395, November, 1929.

The Twentieth Kelvin Lecture. Lightning. Dr. G. C. Simpson, C.B., F.R.S.

Electricity in Agriculture with Special Reference to Electro-Culture. William Phœnix, Associate Member.

Precision Permeability Measurements of Straight Bars and Strips in the Region of High Permeability. C. E. Webb, B.Sc. (Eng.), Associate Member, and L. H. Ford, B.Sc. (Eng.). From the N.P. Lab. Construction of a yoke to give values of $H = 3000$ on straight samples 20 to 25 cm. long and up to 5000 on samples 8 to 10 cm. long is described and also the methods of measuring. The effect of stress in the specimen is considered.

Journal of the American Institution of Electrical Engineers.

September, 1929.

Application of Induction Regulators to Distribution Networks. E. R. Wolfert and T. J. Brosnan.

Annual Report of Committee on Protective Devices, including report of Sub-Committee on Relays.

Annual Report of Committee on Education.

Radio Interference from Line Insulators. Ellis Van Atta and E. L. White. A discussion of the causes of radio interference from insulators on high voltage equipment; the present methods of eliminating disturbance and future designs.

High - Voltage Low - Current Fuses and Switches. Roy Wilkins.

The Interconnected Integraph. Robert E. Glover and Henry H. Plumb. A machine for solving differential equations in two variables.

Annual Report of Committee on Instruments and Measurements.

October, 1929.

Travelling Waves due to Lightning. L. V. Bewley. The purpose is to describe and analyse the origin and formation of waves on a transmission line induced by lightning discharges.

Annual Report of Committee on Communication. Report covers Telephone Transmission, Telephone Service Improvements, Dial Telephony, Carrier Systems, Telephone Plant, Telephone Equipment, Developments in Materials, Airways Communications, Wire Line Systems for Broadcasting, Frequency Control in Radio, Railroad Train, Radio Equipment, Trans-Atlantic Telephony, Trans-Atlantic Telegraphy, Printing Telegraphy, Facsimile Transmission, Television, Sound Pictures, and Municipal and Protective Signalling.

Annual Report of Committee on Research.

The Electrical Engineering of Sound Picture Systems. K. F. Morgan and T. E. Shea. Paper describes the technique and apparatus of sound picture recording and reproduction.

Magnetic Shielding. S. L. Gokhale. The shielding of magnetic instruments from steady stray fields.

November, 1929.

The Theory of Electrical Conductivity. Recent developments. William V. Houston.

Dial Telephone System serving small communities. F. O. Wheelock.

Annual Report of Committee on Transmission and Distribution, Power.

Impulse Insulation Characteristics of Wood Pole Lines. H. L. Melvin. Results of a comprehensive series of tests on power lines.

Annual Report of Committee on Electrical Machinery.

Effect of Surges on Transformer Windings. J. K. Hodnette. Power.

Annal Report of Electrophysics Committee.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	Grade.	Promoted to	Date.
Kingston, J. H.	Acting Assistant Staff Engineer, E.-in-C.O.	Assistant Staff Engineer, E.-in-C.O.	5-11-29
Tattershall, J. T.	Executive Engineer, Exeter Section, S.W. District.	Assistant Superintending Engineer, Scot. E. District.	12-10-29
Shea, J.	Executive Engineer, Leeds Extl. Section, N.E. District.	Assistant Superintending Engineer, N.W. District.	1-1-30
Cameron, J.	Executive Engineer, Glasgow South Section, Scot. West District.	Assistant Superintending Engineer, Scot. West District.	24-9-29
Beeton, H. G.	Acting Exec. Engineer, London District.	Executive Engineer, London District.	16-9-29
Smith, D. Mc.E.	Assistant Engineer, Norwich Section, E. District.	Acting Executive Engineer, Norwich Section, E. District.	16-9-29
	Acting Executive Engineer, E. District	Executive Engineer, E. District.	
Warnock, J. W.	Assistant Engineer, Glasgow Extl. Section, Scot. West District.	Executive Engineer, Glasgow South Section, Scot. West District.	25-11-29
Crompton, W. W. B.	Assistant Engineer, Lines Section. E.-in-C.O.	Executive Engineer, Leeds Extl. Section, N. Eastern District.	1-1-30
Smith, H. A.	Assistant Engineer, Technical Section, London District.	Executive Engineer, West Extl. Section, London District.	1-12-29
Ritter, E. S.	Assist. Engineer, Telegraph Section. E.-in-C.O.	Executive Engineer, Telegraph Section, E.-in-C.O.	1-4-30
Hill, H.	Assist. Engineer Equipment Section, E.-in-C.O.	Executive Engineer, (location to be fixed later).	1-4-30
Morgan, J.	Assist. Engineer, Lines Section, E.-in-C.O.	Executive Engineer, Exeter Section, S.W. District.	15-12-29
Hannaford, F. S.	Asst. Engineer, S. East District.	Executive Engineer, N. Wales Dist.	
Innes, J.	Asst. Engineer, Scot. East Dist.	Executive Engineer, Scot. West Dist.	
Tite, W. G.	Chief Inspector, London District.	Assist. Engineer, Telephone Section, E.-in-C.O.	18-9-29
Frost, J.	Chief Inspector, N. Wales District.	Assistant Engineer, Nottingham Section, N.Mid. District.	1-10-29
Sinclair, R.	Chief Inspector, London District.	Assistant Engineer, London District.	12-12-29
Wilkie, E. D.	Chief Inspector, Northern District.	Assistant Engineer, London District.	1-1-30
Smith, R. P.	Chief Inspector, E.-in-C.O.	Assistant Engineer, E.-in-C.O.	12-12-29
Powell, H. W.	Chief Inspector, N. Wales District.	Assist. Engineer, S. Lancs. District.	To be fixed later.
Leithead, W.	Chief Inspector, Scot. East District.	Assistant Engineer, Scot. E. District.	1-1-30
Graham, R. S.	Chief Inspector, Northern District.	Assist. Engineer, S. Lancs. District.	To be fixed later.
Smith, H. G.	Chief Inspector, Eastern District.	Assistant Engineer, Eastern District.	To be fixed later.
Parker, N. W.	Chief Inspector, London District.	Assistant Engineer, E.-in-C.O.	12-12-29
Satchwell, W. A.	Chief Inspector, S. Lancs. District.	Assist. Engineer, S. Lancs. District.	12-12-29

PROMOTIONS (*continued*).

Name.	Grade.	Promoted to	Date.
Judd, F. J.	Chief Inspector, London District.	Assistant Engineer, E.-in-C.O.	To be fixed later.
Baker, T. W.	Chief Inspector, S.W. District.	Assistant Engineer, E.-in-C.O.	To be fixed later.
Naylor, G.	Inspector, S.W. District.	Chief Inspector, S.W. District.	28-4-29
Stokes, G. W.	Inspector, S.E. District.	Chief Inspector, S.E. District.	18-12-27
Browning, W. H.	Inspector, London District.	Chief Inspector, London District.	19-12-28
Law, C. V.	Inspector, N. Wales District.	,, ,,	29-3-29
McIntosh, J.	Inspector, Scot. East District.	Chief Inspector, Scot. East District.	26-1-29
Vernon, R. J.	Inspector, S. Lancs. District.	Chief Inspector, E.-in-C.O.	10-4-29
Mayman, A. C.	Inspector, N. East District.	Chief Inspector, E.-in-C.O.	21-4-29
Arnold, A.	Inspector, Scot. West District.	Chief Inspector, E.-in-C.O.	11-4-29
Lynn, B.	Inspector, E.-in-C.O.	Chief Inspector, E.-in-C.O.	21-11-28
Howrigan, H. F.	Inspector, Testing Branch.	Chief Inspector, Testing Branch.	21-2-29
Davies, H. S.	Skilled Workmen, Cl. I., N. Wales District.	Inspector, N. Wales District.	To be fixed later.
Moores, H. J.	Skilled Workmen, Cl. I., S. Lancs. District.	Inspector, S. Lancs. District.	
Devereux, S. F. W.	Skilled Workmen, Cl. I., London District.	Inspectors, London District.	
Header, S. O.			
Stowell, A. C. St. J.			
Byme, W. G.			
Sanger, C.			
Gooch, J. V. L.			
Nightingale, W. H.			
Lockie, R. A.			
Brown, W. J.			
Hicks, C. J.			
Burrows, C. T.	Skilled Workmen, Cl. I., S. E. District.	Inspector, S.E. District.	

RETIREMENTS.

Name.	Rank.	Districts.	Date.
Comport, Major G. H., M.C. ...	Assistant Superintending Engineer.	N. Ireland.	30-9-29
Wallace, G. S.	,,	N.E.	31-12-29
Cowie, J.	Executive Engineer.	London.	30-11-29
Hetherington, T.	,,	Scot. West.	31-12-29
Gwyer, J. H.	Assistant Engineer.	London.	31-12-29
Walby, W. F.	,,	,,	30-11-29
Ives, G. T.	Inspector.	,,	31-8-29
Harris, W. R.	,,	,,	31-1-29
Price, H. G.	,,	S. Wales.	13-10-29
Comport, T.	,,	London.	20-11-29

DEATHS.

Name.	Rank.	District.	Date.
Hansford, Dr. R. V.	Assistant Staff Engineer.	E.-in-C.O.	5-10-29
Evers, J. H.	Inspector.	S. Wales.	31-8-29
Graves, K. G. R.	,,	London.	4-9-29

TRANSFERS

Name.	Rank.	From	To	Date.
Horner, F. H.	Executive Engineer	N. Wales District.	E.-in-C.O.	17-11-29
De Wardt, R. G.	,,	Grimsby Radio.	E.-in-C.O.	29-9-29
Faulkner, H.	,,	Rugby Radio.	E.-in-C.O.	8-10-29
Struthers, G. A.	,,	Bodmin Radio.	Rugby Radio.	29-9-29
Lock, F.	,,	E.-in-C.O.	S. Mid. District.	1-10-29
Hanford, S.	Assistant Engineer	E.-in-C.O.	S.E. District.	3-11-29
King, A. G.	Chief Inspector	Bridgwater.	S. Mid. District.	29-9-29
Wain, S. W.	,,	Bodmin Radio.	Rugby Radio.	29-9-29
Robinson, R. P.	,,	Grimsby Radio.	E.-in-C.O.	29-9-29
Kennard, T. G.	,,	E.-in-C.O.	London District.	24-10-29
Hinton, H.	Repeater Officer, Cl. I.	Harbour Grace. Newfoundland.	Communications Coy.	29-9-29
Hutchison, D. C.	Acting Inspector.	Grimsby Radio.	Communications Coy.	29-9-29
Richardson, A. E.	Inspectors.	Grimsby Skegness Radio.	Colney Heath Radio.	29-9-29
Bateson, E. L. H.		Grimsby Skegness Radio.	Baldock Radio.	29-9-29
Macqueen, J. J.		Grimsby Skegness Radio.	Rugby Radio.	29-9-29
Wade, W.		Bodmin Bridgwater Radio.	Portishead Radio.	29-9-29
Woodhead, H. C.		Bodmin Bridgwater Radio.	Rugby Radio.	29-9-29
Stewart, T.		Bodmin Bridgwater Radio.	Baldock Radio.	29-9-29
Thomsett, H.		Bodmin Bridgwater Radio.	Rugby Radio.	29-9-29
Lynes, F. A.		Grimsby-Skegness Radio.	Leafield Radio.	29-9-29
Shephard, A. C.		Leafield Radio.	Rugby Radio.	29-9-29
Cooper, W. D.	Inspector.	Rugby Radio	E.-in-C.O.	10-11-29
Law, C. V.	Chief Inspector.	London District.	N. Wales District.	6-10-29

CLERICAL ESTABLISHMENT.

RETIREMENTS.

Name.	Grade.	District.	Date.
Miller, W	Higher Clerical Officer.	Scot. East.	29-9-29

TRANSFERS.

Name.	Rank.	From	To	Date.
Norman, R. D. S.	Higher Clerical Officer.	Northern District.	Scot. East.	10-11-19

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